Environmental footprint of our products via Life Cycle Assessment (LCA)

We offer renewable products with minimal environmental footprint to move towards biobased circular economy. How?

We valorize locally generated forestry and wood industry residues that originate only from sustainably managed forests within 50 km radius. Also, our innovative fractionation process will convert more than 90% of woody biomass into high-value products with minimal environmental impact as our plant runs 100% on renewable energy.

To support our customers to make conscious choices, all our products are subject to evaluation of environmental performance also known as Life Cycle Assessment (LCA).

What is LCA?

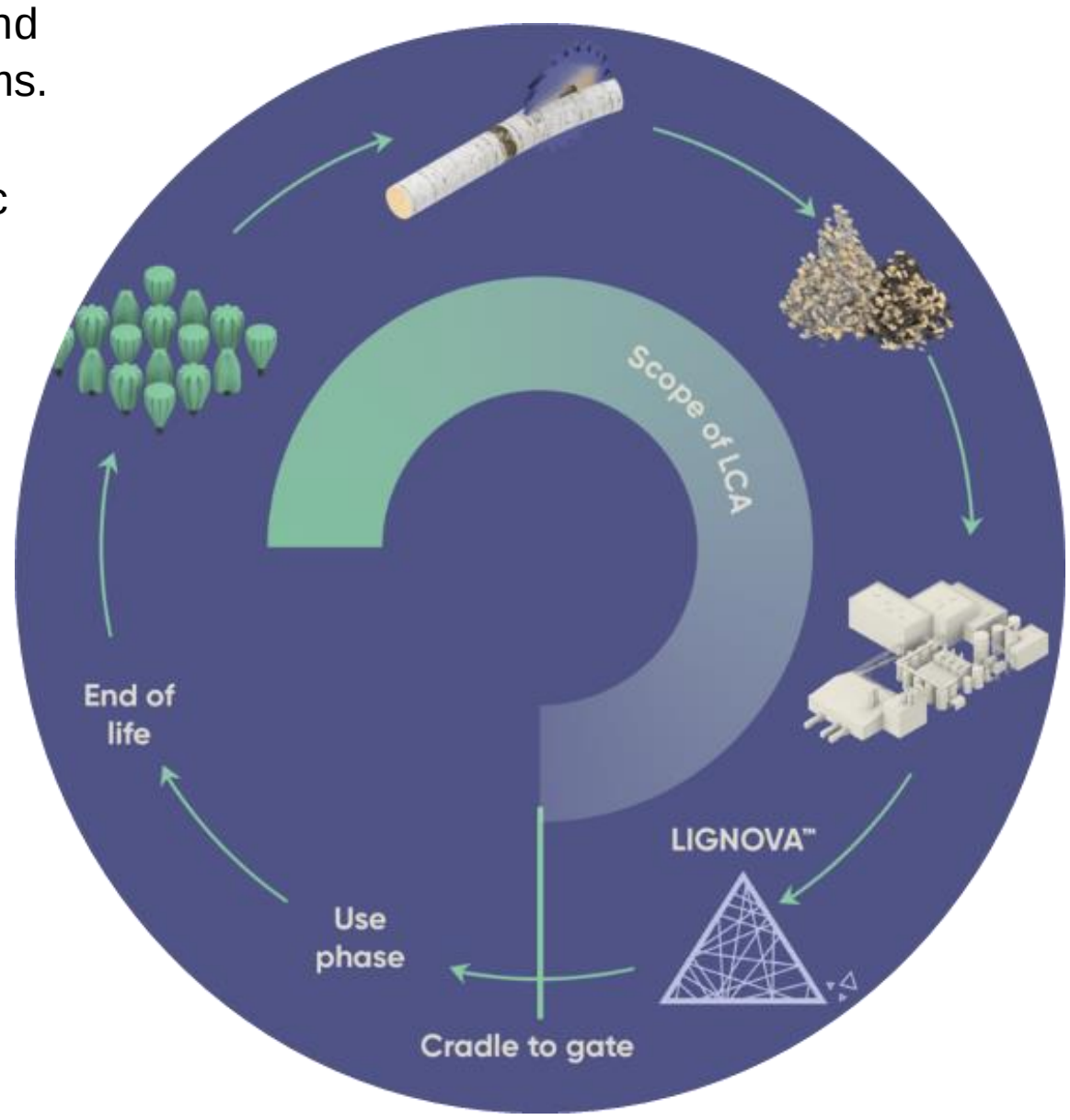
Shortly, LCA is a methodology which aims to quantify and evaluate the environmental impacts associated with a product, process, or service throughout its entire life cycle. Some of the most relevant aspects under consideration include water and land use, greenhouse gas emissions and energy consumption.

Results of LCA reflect environmental impacts and help to compare products, processes, or systems. This allows to adjust and optimize processes, helping to make informed decisions on scientific basis.

Life Cycle Assessment (LCA) of our fractionation process

The scope of our LCA covers forestry, wood processing and fractionation process itself – this is called cradle-to gate approach.

Cradle-to-gate means that LCA covers product life cycle from resource extraction (forestry, in our case) to our factory gate (selling our process outputs- cellulosic sugars, specialty celluloses and lignin).



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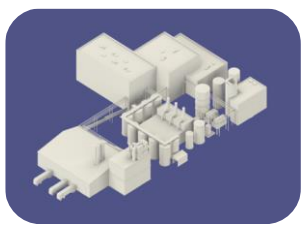
Forestry – The wood residues we use originate only from sustainably managed forests. We check that all roundwood connected to our input materials is harvested from certified forests and through certified supply chains. Examples of forestry leftovers are defective logs and spoilt wood.

Wood processing – The criteria of using only inputs from certified forests and supply chains also applies to residues and leftovers from wood processing industry. Residues from wood processing could be in the form of sawdust, chipped wood, off-cuts and defective logs.



Fractionation process – Our flagship plant uses Sweetwater Energy Sunburst pretreatment technology, during which wood is deconstructed into its basic components. The process uses heat, pressure, dilute acid and mechanical power to turn wood chips into a chocolate mousse-like slurry that is further converted into biomaterials. The fractionation process is efficient and fast (taking only 20 seconds to turn wood chips into wood slurry).

Products – Our product portfolio includes cellulosic sugars, specialty celluloses and high purity lignin (Lignova™).

Data in brief

Goal and scope:	Evaluation of environmental impacts of the fractionation process
Reference documents:	ISO 14040-14044
Software:	SimaPro 9.3
Allocation:	multi-output allocation (economic, NCV, mass)
Functional unit:	entire fractionation process
System boundaries:	cradle-to-gate
Primary data:	operational data from 2017, 2021-2022
Secondary data:	ecoinvent v3.8 database
Methods:	EF 3.0, ReCiPe 2016 Endpoint H/A, IPCC 2021 GWP100 method
Carbon:	carbon neutrality approach

Carbon neutrality – At the moment there are heated discussions on the topic of biogenic carbon accounting in LCA calculations. The bio-based products industry is fighting to include the biogenic carbon credit to the equation even though most standards and guidelines on LCAs do not support that. In general, to subtract the carbon credit in cradle- to-gate study the biogenic carbon must remain stored for more than 100 years. In our case, as the products have many different possible applications and the end-of life phase is excluded from our LCA studies (cradle-to gate), accounting carbon credit would not be appropriate.

Allocation method – The LCA impact assessment results could depend significantly on the choice of allocation method and currently there are no standardized LCA approach for biobased chemicals coproduct flows. We have investigated 3 different allocation methods (economic, net calorific value (NCV) and mass) for our products and the economic allocation was chosen to maintain consistency with the model that was developed for wood residues.

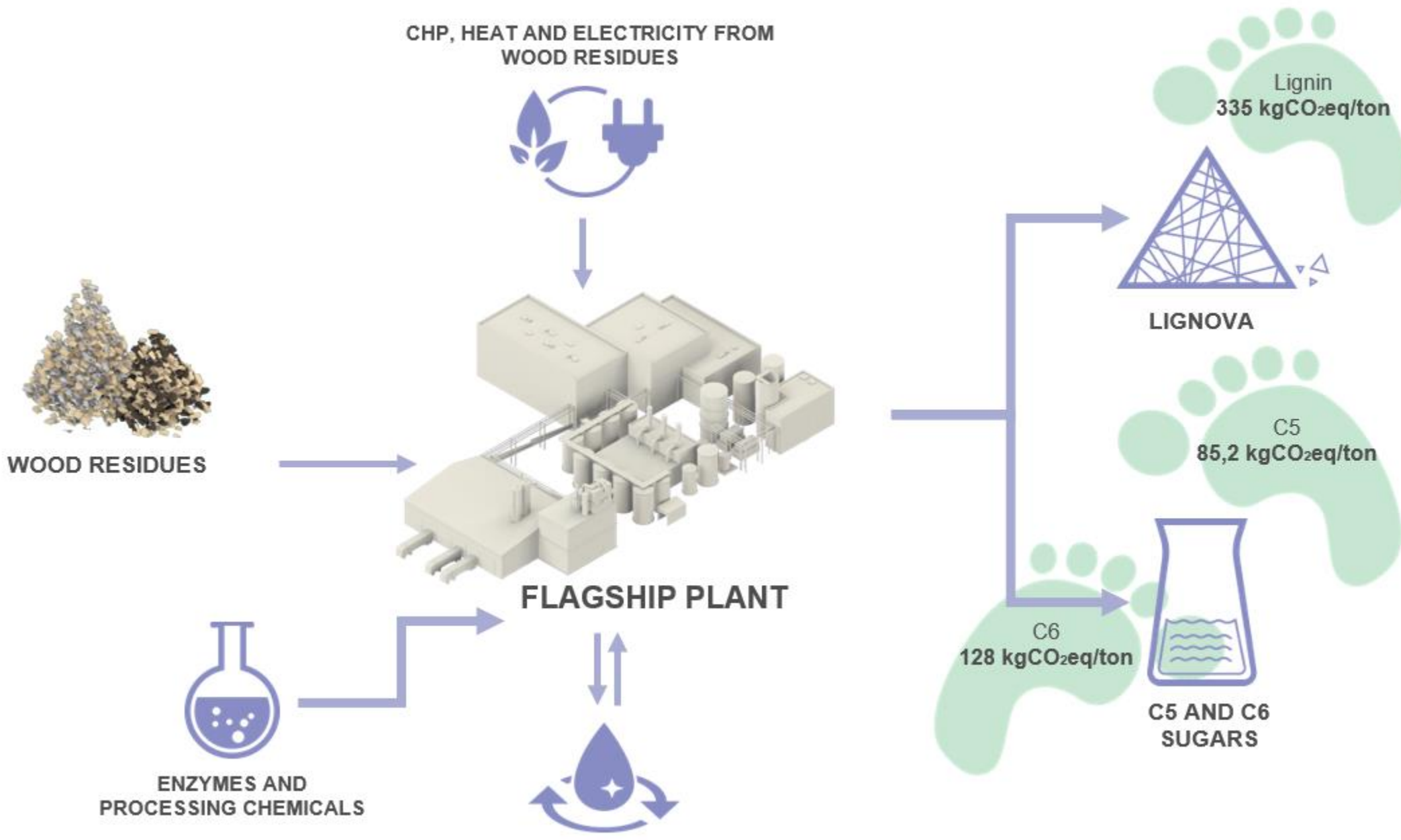
info@fibenol.com | www.fibenol.com

Life Cycle Impact Assessment (LCIA)

LCIA is a part of LCA that evaluates potential environmental impacts. Used methods for our calculations include:

- **IPCC 2021 GWP100** – Contains climate change factors of IPCC with a timeframe of 100 years, excluding the CO_2 uptake. It is used to calculate carbon footprint.
- **EF 3.0** – Covers 16 main impact categories (climate change; ozone depletion; ionizing radiation; photochemical ozone formation; particulate matter; human toxicity, non-cancer effects; human toxicity, cancer effects; acidification; eutrophication freshwater; eutrophication marine; eutrophication terrestrial; ecotoxicity freshwater; land use; water use; resource use, fossils; resource use, mineral and metals).
- **ReCiPe 2016 Endpoint H/A** – Covers 17 impact categories that can be further aggregated into 3 damage categories (damage to human health, damage to ecosystem quality, damage to resources).

Carbon footprint of our products



Carbon footprint of lignin, C5 and C6 sugars kg CO_2 per ton final products

(IPCC 2021 GWP100)

The interpretation of carbon footprint depends on the definition of functional unit. For example, carbon footprint of our whole fractionation process is **201 kg CO2 eq** based on 1 ton of dry input material (wood residues). To put it into perspective, yields form 1 ton of dry wood range from:

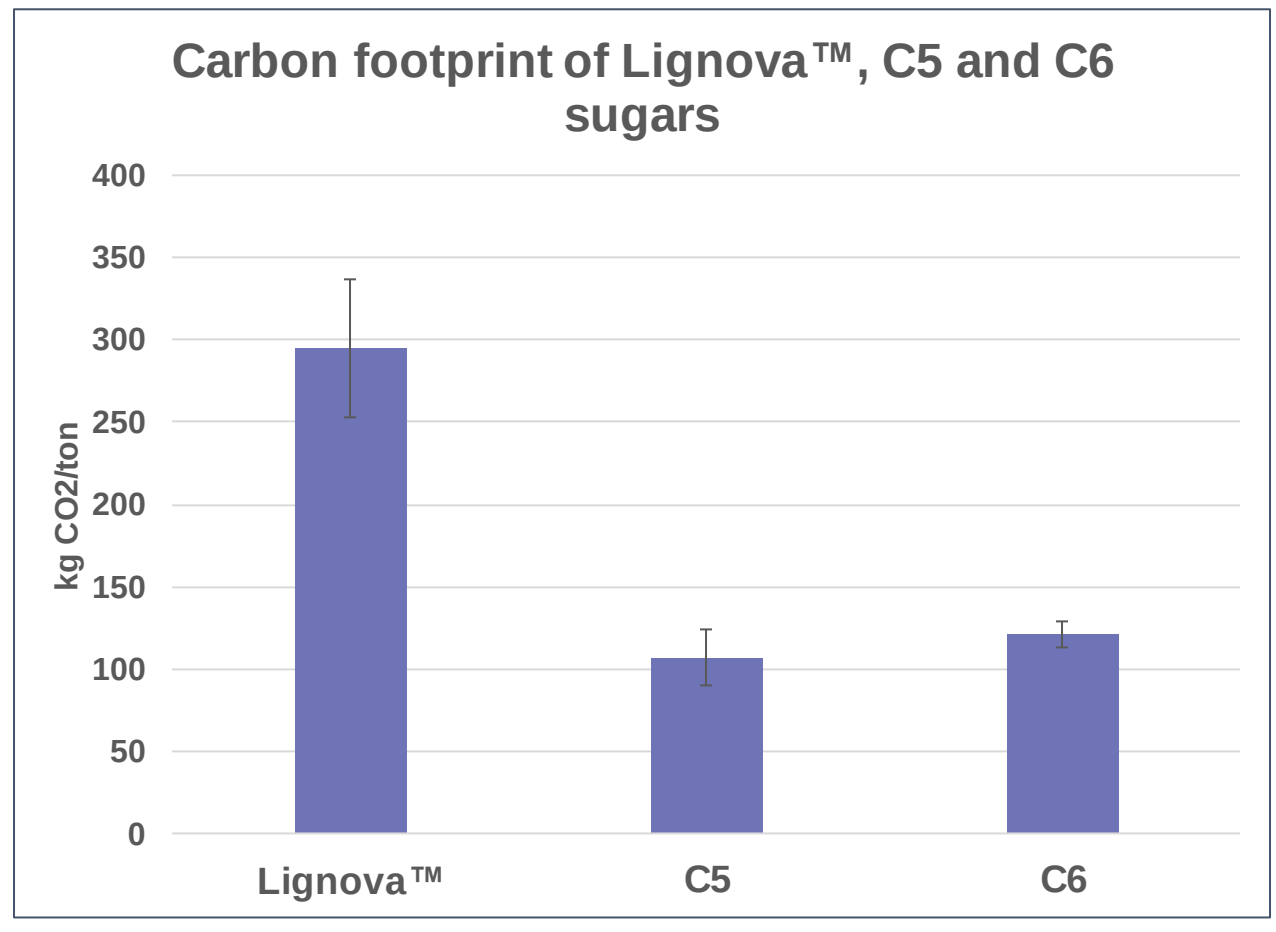
Lignin: 200-300 dry kg/t dry wood

C5 sugars: 300-400 dry kg/t dry wood

C6 sugars: 400-500 dry kg/t dry wood

Carbon footprint of each individual product depends on selected allocation method. As our products have possible applications in different sectors, 3 different allocation methods (economic, NCV and mass) are considered. Values considering different allocation are presented as range:

	Carbon Footprint kg CO_2 eq/ton
Lignin	237…335
C5 sugars	85…126
C6 sugars	110…128



Besides carbon footprint, other environmental hotspots are also evaluated through contribution analysis.

The biggest contributors to our environmental impacts are usage of enzymes and sodium hydroxide in our production.

The LCA study of the SWEETWOODS fractionation process is carried out by project partner 2B Srl.

info@fibenol.com | www.fibenol.com