Life cycle assessment of the Kuura® textile fibre

Summary by Metsä Group (dated January 27, 2025) of a Life Cycle Assessment study of Kuura® textile fibre performed by Etteplan (report dated October 30, 2024, report v3.0), which was critically reviewed by RISE Research Institutes of Sweden (respective report dated November 8, 2024)

Goal and scope

Objective	A life cycle assessment (LCA) of Kuura® textile fibre (man-made cellulosic fibre).
Declared unit	1 tonne of Kuura staple fibre, packed into bales and ready at the mill gate.
System boundary	Cradle-to-gate
Assumptions	Production of Kuura fibre would be integrated to a host mill, i.e., to Metsä Group's bioproduct mill in Äänekoski, Finland. The inventory data of the Kuura production process was based on the newest available design values from September 2024, representing a possible mill with annual production of 100,000 tonnes of Kuura fibre.
Standards and impact assessment	Assessment was made according to the ISO 14067, ISO 14040 and ISO 14044 standards. All PEF-recommended impact categories were assessed with the EF 3.1 methods, except for the global warming potential (GWP) assessment, in which the ISO 14067 compliant method was applied.

Standards, tools and methodologies used

The assessment was conducted in line with the following standards: CFP standard ISO 14067:2018 and LCA standards ISO 14040:2006 and 14044:2006. To ensure the quality of the assessment, a critical review was performed by RISE Research Institutes of Sweden.

The assessment was covering a partial product life cycle, i.e. from resource extraction (cradle) to the mill gate (before the product would be transported to the consumer). No major cut-offs exists in the assessment. No categorised co-products were assumed to be generated linked to the Kuura production and thus, no allocation between Kuura and other output flows was needed. Allocation of the pulp mill operations (pulp production, electricity and steam production) was based on economic values (revenues). Year 2023 prices were applied.

The impact categories of the Environmental Footprint (EF) method by the European Commission were assessed. The newest available impact assessment method according to EF (EF 3.1) was applied. Moreover, the dedicated method in LCA for Experts software was used.

Primary data was used for all Metsä Group operating processes. Pulp production and other common operations in Äänekoski were based on annual data for 2023. The data for the Kuura production process was based on the newest design data for a possible 100,000 tonnes per year mill (design data completed in September 2024). Secondary data was applied in the assessment only for the background operations: Sphera professional (2024.2) and Ecoinvent (3.10)

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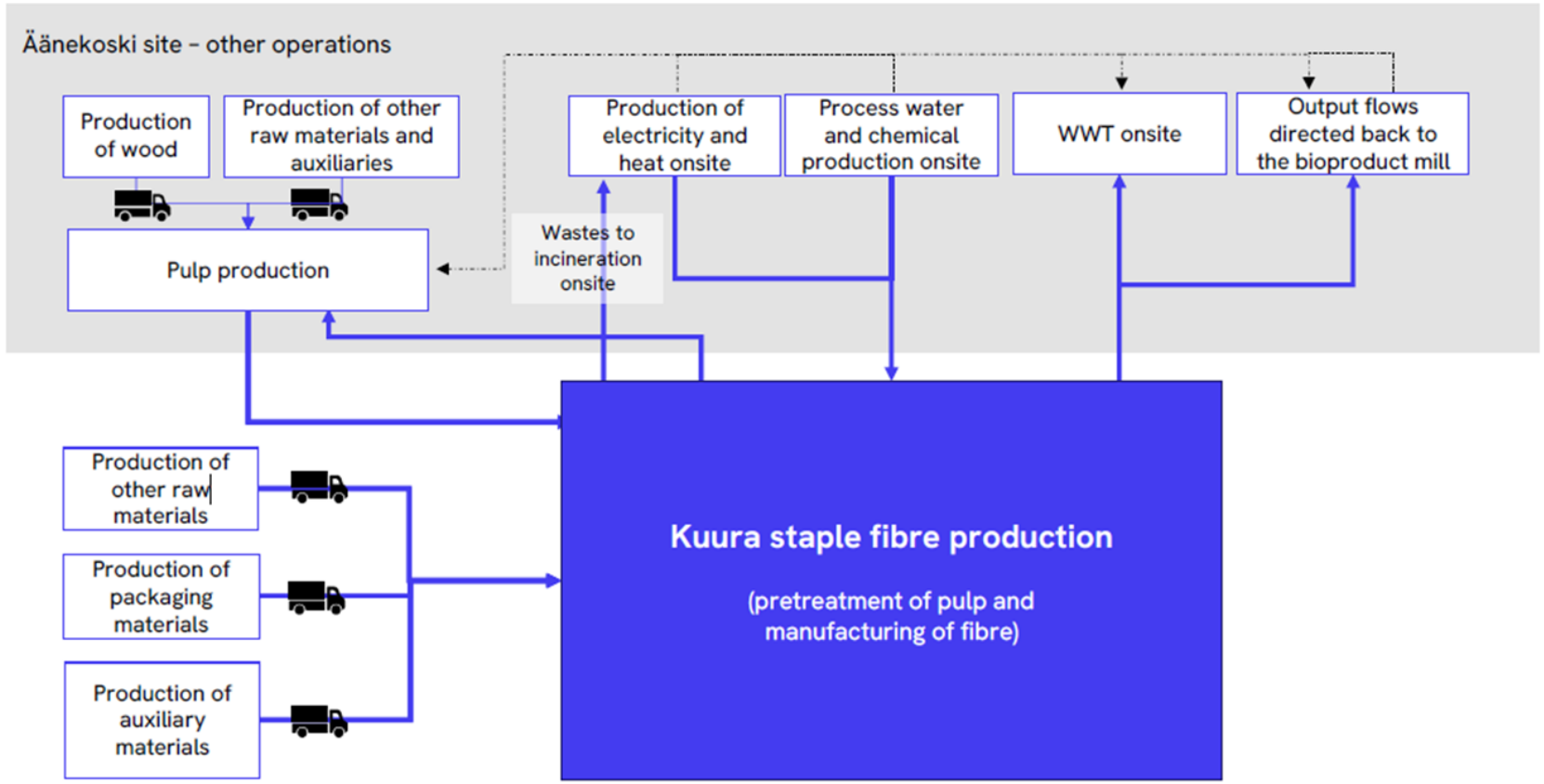
System boundary



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Results - categorisation

Category	Description, included totalities
Pulp production	Production of pulp, including forestry operations and pulp (bioproduct) mill activities.
Pulp pre-treatment	Acquisition of raw materials and manufacturing of chemicals before being transported to Äänekoski site. Upstream electricity and steam production activities. Electricity and steam consumption in pulp pre-treatment process, as well as the increased consumption of both electricity and steam in the bioproduct mill, due to the Kuura production process. Demineralised (demi) water production.
Lyocell process	Dissolving the pre-treated pulp in an organic solvent, spinning and eventually making the staple fibre. Acquisition of raw materials and manufacturing of chemicals before being transported to the Äänekoski site. Upstream electricity and steam production activities. Electricity, steam consumption in Lyocell-type of process entity, as well as the increased consumption of both electricity and steam in the bioproduct mill, due to the Kuura production process. Wastewater treatment and demi water production.
Integration	Acquisition of raw materials and manufacturing of calcium oxide before being transported to the Äänekoski site. NOx emissions. Upstream electricity and steam production activities. Electricity and steam consumption in the chemical recovery unit operations at the bioproduct mill.
Transportation of all inputs	Transportation of all chemicals as well as transportation of packaging materials and chemicals used in the wastewater treatment plant.
Packaging materials	Production of a cardboard wrap and polyester yarn.

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LCIA results for 1 tonne of Kuura textile fibre

Indicator	Unit	Quantity
Global warming potential, total	kg CO_2 eq.	418
GWP fossil	kg CO_2 eq.	389
GWP biogenic	kg CO_2 eq.	26
GWP dLUC	kg CO_2 eq.	2.25
Ozone depletion	kg CFC-11 eq.	5.14E-06
Acidification	mol H^+ eq.	5.74
Eutrophication, freshwater	kg P eq.	7.82E-02
Eutrophication, marine	kg N eq.	3.75
Eutrophication, terrestrial	mole of N eq.	28.0
Photochemical ozone formation, human health	kg NMVOC eq.	7.0
Resource use, minerals and metals	kg Sb eq.	6296
Resource use, fossils	MJ	8.63E-04
Water use	m^3 world eq.	127
Land use	Pt (points)	305223
Particulate matter	Disease incidences	2.38E-05
Ionizing radiation	kBq U^{235} eq.	45.6
Human toxicity, cancer (total)	CTUh	2.83E-07
Human toxicity, non-cancer (total)	CTUh	3.99E-06
Ecotoxicity, freshwater	CTUe	2936

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Contribution of life cycle stages to EF impact categories (%)

Contribution of life cycle stages to EF impact categories (%)	Pulp production	Pulp pre-treatment	Lyocell process	Integration	Transportation of all inputs	Packaging materials
Acidification	31.3	2.1	21.7	42.9	1.8	0.2
Climate change, total	46.6	3.8	44.3	2.5	1.7	1.1
Climate change, biogenic	60.7	4.3	34.0	0.9	0.0	0.1
Climate change, fossil	45.6	3.8	45.1	2.6	1.9	1.1
Climate change, land use and land use change	61.1	3.7	31.8	0.9	1.8	0.8
Ecotoxicity, freshwater	40.3	3.8	51.5	0.8	2.3	1.4
Eutrophication, freshwater	79.2	1.9	18.4	0.4	0.0	0.1
Eutrophication, marine	21.4	1.5	41.4	34.5	1.1	0.1
Eutrophication, terrestrial	28.1	2.0	17.7	50.5	1.6	0.2
Human toxicity, cancer	46.8	2.1	49.5	0.6	0.4	0.4
Human toxicity, non-cancer	43.2	3.6	47.9	2.9	1.2	1.1
Ionising radiation	64.3	7.5	27.1	0.2	0.0	0.8
Land use	62.8	3.9	32.1	0.9	0.0	0.3
Ozone depletion	85.9	1.1	12.7	0.3	0.0	0.0
Particulate matter	33.4	2.7	30.9	23.1	9.1	0.8
Photochemical ozone formation	29.4	2.0	19.5	47.2	1.6	0.2
Resource use, fossils	43.9	3.6	48.8	0.9	1.4	1.4
Resource use, minerals and metals	68.8	1.1	29.7	0.2	0.0	0.1
Water use	90.7	-1.1	9.8	0.1	0.0	0.4

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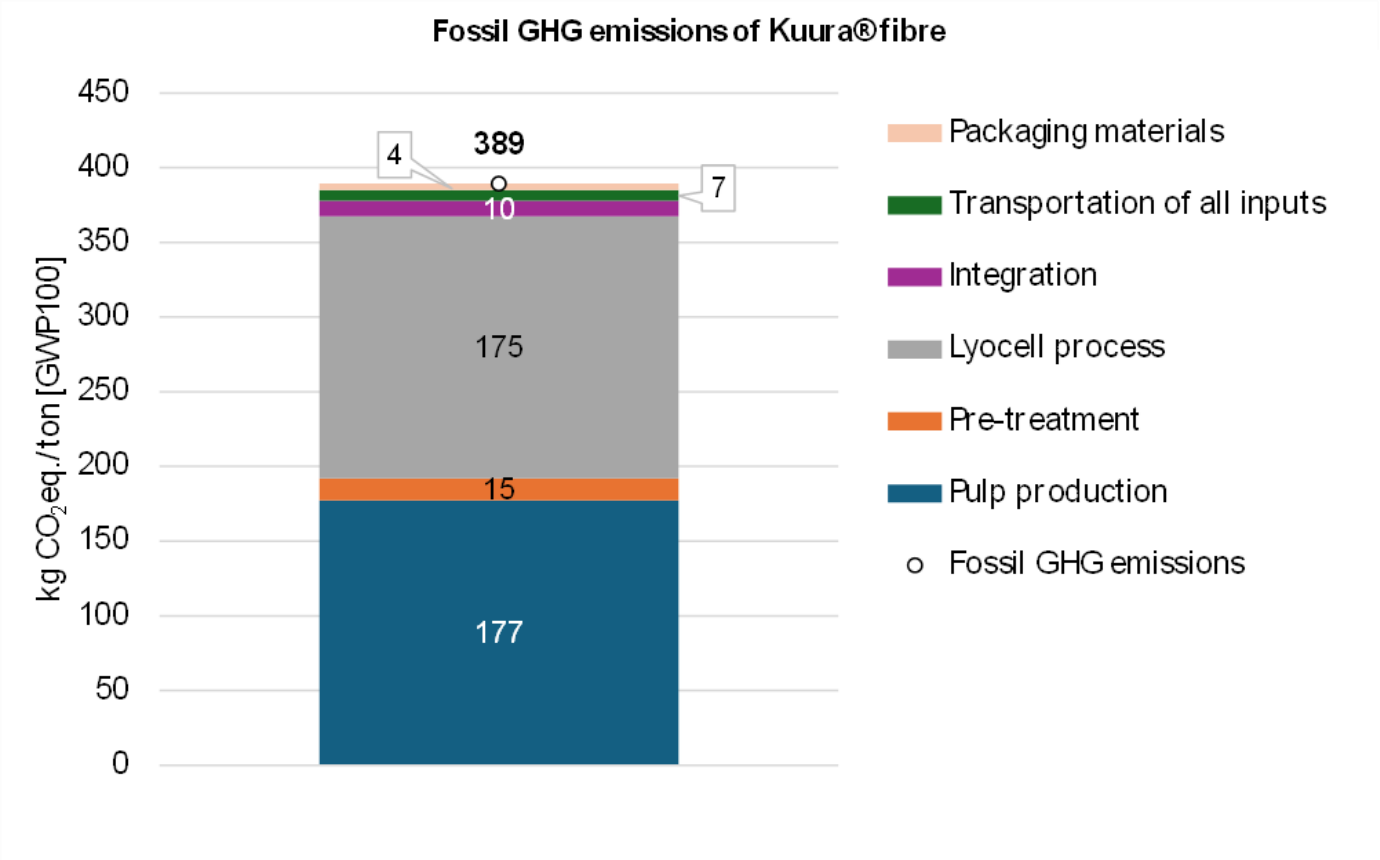
Fossil GHG emissions of Kuura textile fibre



Fossil greenhouse gas (GHG) emissions of producing Kuura fibre stem from, especially, 'Pulp production' (46%) and 'Lyocell process' 45%).

The main contributors to the former are bleaching (30%) forestry operations (28%) and cooking (26%).

The main contributors to the latter are steam production (44%), solvent (24%) and electricity (11%).

General comment, applies to all results: Since the electricity and steam are co-products of the bioproduct (pulp) mill, they acquire same burdens from cooking and upstream processed as pulp, but none from bleaching and drying since electricity and steam are gained already from the cooking stage.

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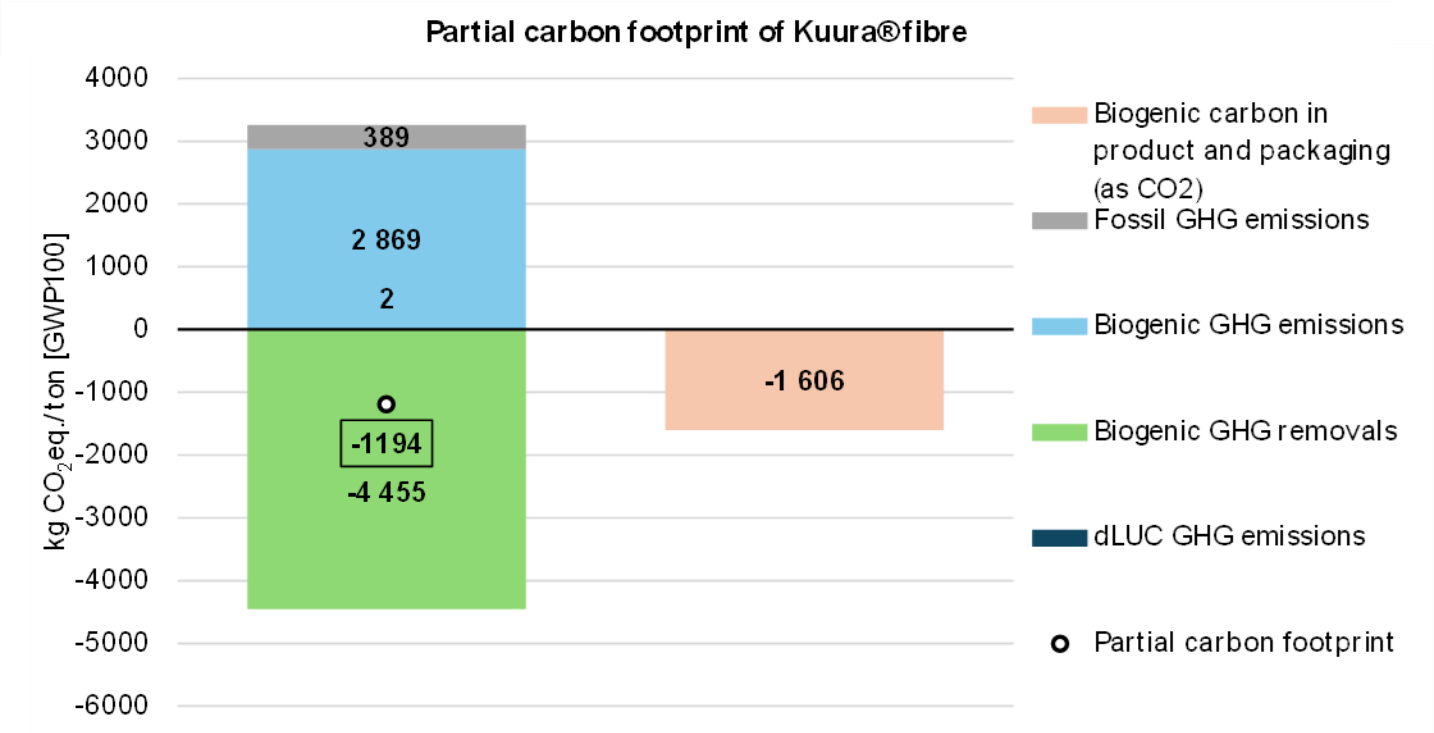
GWP total – a partial carbon footprint



According to the ISO14067:2018 method. Since system boundary is from cradle-to-gate and not cradle-to-grave, term “partial carbon footprint” should be used instead of “carbon footprint”

Fossil greenhouse gas (GHG) emission is 12% of all GHG emissions. The rest, biogenic GHG emission, is thus 88% of all emissions.

Direct land use change (and aircraft) GHG emissions are negligible.

All biogenic carbon content of Kuura fibre is due to the pulp incorporated in it and the cardboard wrap packaging material.

How to read biogenic results: Biogenic GHG removals + Biogenic GHG emissions ≈ Biogenic carbon in product. Not an exact match due to part of removal (CO2) being released as methane (CH4) at some point (CH4 has higher CO2e factor).

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Conclusions

There is no single life cycle stage or flow for the studied product that would be the most important for all studied environmental impact indicators.

Depending on the studied indicator the most important life cycle stages are pulp production, lyocell process, and integration processes. Pulp production is the most significant life cycle stage for most of the environmental impact indicators, as it is also 88% of the product weight.

Lyocell process primarily causes impacts due to electricity and steam consumption, as well as due to the use/production of an organic solvent. Electricity and steam, co-products of pulp production, share the same environmental impacts as pulp but none from bleaching and drying.

Integration processes contribute to multiple environmental categories, with organic solvent losses routed to the bioproduct mill, contributing to NOx emissions through black liquor combustion.

Pulp pre-treatment process, production of packaging materials, and transportation of all inputs have minimal impact.

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References

Ecoinvent. 2024. Ecoinvent 3.10 database (cut-off system model).

ISO 14040. 2006. Environmental management – Life cycle assessment – Principles and framework.

ISO 14044. 2006. Environmental management – Life cycle assessment – Requirements and guidelines.

ISO 14067:2018. Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification.

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