Proceedings of the 63rd International Convention of
Society of Wood Science and Technology
July 12-17, 2020 – Hoteli Bernardin, Portorož, Slovenia

STRATEGIES TO MINIMIZE THE ENVIRONMENTAL FOOTPRINT OF WOOD AND ENGINEERED WOOD PRODUCTS

*Erwin M. Schau**
Researcher (PhD)
InnoRenew Centre of Excellence (CoE), Izola - Isola (Slovenia)
* *Corresponding author: erwin.schau@innorenew.eu*

Abstract

Reducing the environmental impacts of products and activities becomes more and more important as the world's population grows and limits of the earth's carrying capacity are closing in or already exceeded. Wood and engineered wood products, coming from a natural source, are generally seen as more environmentally sound than alternative products and materials. However, to keep up with the general development of environmental efficiency (i.e., less environmental impact per produced unit), wood and engineered wood products should also improve their environmental footprint. In this contribution, the standardized method of life cycle assessment is used to investigate a range of wood and wood products with a focus on building materials, like glued-laminated timber (glulam) and oriented strand boards. Where data permits, the Environmental Footprint indicators as recommended by the European Union, are applied. The results are used to highlight fields of improvement and strategies for an even lower environmental profile for wood materials and products and could be of interest for producers as well as purchasers and users of materials and products based on wood materials. By combining all strategies, a reduction of the overall environmental footprint by up to ca 60 % was achieved.

Key words: environmental impact, engineered wood products, optimization, oriented strand board (OSB), glued-laminated timber (glulam)

Introduction

Wood products have been used for centuries, have a natural origin and are generally seen as an environmentally sound material (Obućina et al, 2017). However, as the world's population grows (United Nations, 2019), so does also the use of materials and products and their accompanying environmental impact (Crippa, 2019). The carrying capacity of our one and only world is limited; therefore, environmental efficiency (i.e., less environmental impact per produced unit) strategies are needed to cope with larger demand from a growing world population. This is also valid for wood products, especially in the building sector where engineered wood products could play a significant role as the core for high rise mass timbered buildings (Ramage et al. 2017). As competing products to wood, like concrete, steel and glass, are not sleeping but working to continuously improve the environmental footprint of their product, so should the wood industry in order to not be left behind.

This contribution applies the standardized method of life cycle assessment (LCA) (ISO14040/44 (2012), cradle-to-gate, to investigate a range of wood and wood products with a focus on building materials like glued-laminated timber (gluelam) and oriented strand boards (OSB). Where data permits, 13 different Environmental Footprint (EF) indicators, as recommended by the European Union (2020), are applied. The results are used to highlight fields of improvement and strategies for an even lower environmental profile for wood materials and products that could be of interest for producers as well as purchasers and users of materials and products based on wood materials.

Materials and Methods

EcoInvent database v 3.5 (Ecoinvent, 2018), as implemented in the LCA software SimaPro v 9.0 (Pré Consultants 2019), is used for this analysis. This database includes a range of different life cycle inventories for building materials and wood products. The cut-off system modelling and global (or rest of the world) geographical data has been used as a reference. The cradle-to-gate system boundary, including forestry operations, transport and manufacturing, has been chosen. For the life cycle impact assessment, the EU Environmental Footprint indicators are applied, except the toxicology impact categories, which are replaced by newer ones not yet implemented in the software used.

The starting point for different strategies (or parameters) of influence has been chosen with the background that the production itself is to a large extent already optimized. This might be more or less the case. Then, environmental impact reducing potential also outside the direct control of the producing company, but still under some control (for example, buying decisions), has been investigated. Seven strategies to reduce the environmental footprint of OSB and glulam products are investigated. These are presented in Table 1.

Table 1: Description of strategies reported

Strategy		
No.	Name	Description
1	Reduce the amount of glue (low glue)	Resins are reduced by 20 % (amount, but similar effect if the environmental impact of the resin is reduced by 20 %)
2	Modal shift to train	Transport by ship and heavy-duty vehicle is performed by train (200 km) instead
3	Local supply of wood raw material	The production site is located near the wood source, such that local sourcing (50 km lorry) is possible

4	Clean electricity	All electricity is coming from renewable sources (100 % waterpower from river)
5	Biomass heat only	(not glulam) Fossil energy sources (natural gas and oil) for heat production is replaced with biomass (wood chips)
6	Reduced wood input	Wood need is reduced by 10 % (amount, but same effect if the environmental impact of the wood raw material is reduced by 10 %)
7	Combined	Combination of several strategies (see above; Glulam: no. 1,3,4 and 6; OSB: no. 1,3-6)

No. 5, *Biomass heat only*, is applied only in the OSB case, as heat from biomass is already implemented in glulam reference production. The different strategies are combined in no. 7, with the exception of no. 2, *Modal shift to train*, as this is not realistic for local (50 km) supply of wood (where no. 3 is applied to reduce the impact from transport of raw materials).

Results and Discussion

Results are presented in Figure 1 (glulam) and Figure 2 (OSB) and show the reduction for each strategy adjusted for each of the investigated environmental footprint impact categories (measured in percentage). The characterized results are reported in Annex I and II for better transparency. The results show that the combined strategy, as expected, leads to the highest reduction, up to 60 % for climate change (glulam). Clean electricity is a very promising single strategy for both glulam and OSB.

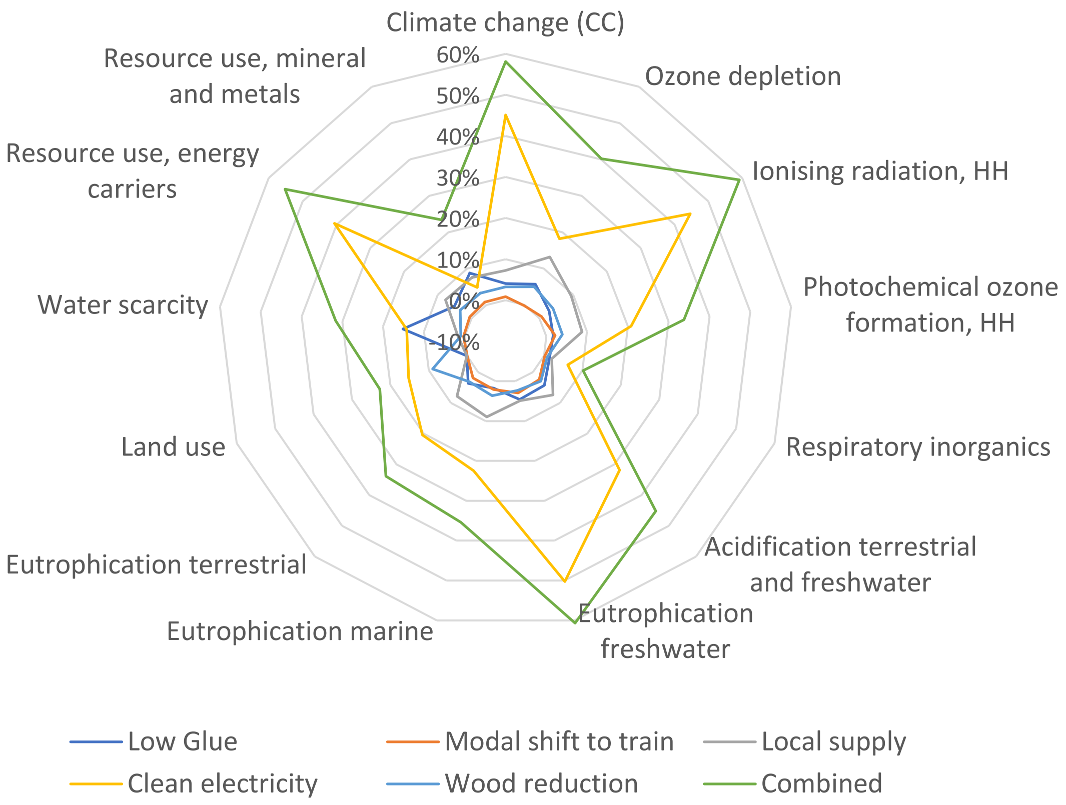

Figure 1. Reduction potentials for different strategies in relation to no action-reference for glued-laminated timber (glulam), depicted for different environmental impacts.

Investigated strategies optimization for glulam lead to a reduction of 0 % for low glue in the land use impact indicator and up to 50 % for clean electricity in the eutrophication freshwater impact category, followed by 45 % in climate change and ionizing radiation impact categories. The respiratory inorganics impact category is difficult to reduce; in total for the combined strategy, only 10 % reduction is achieved.

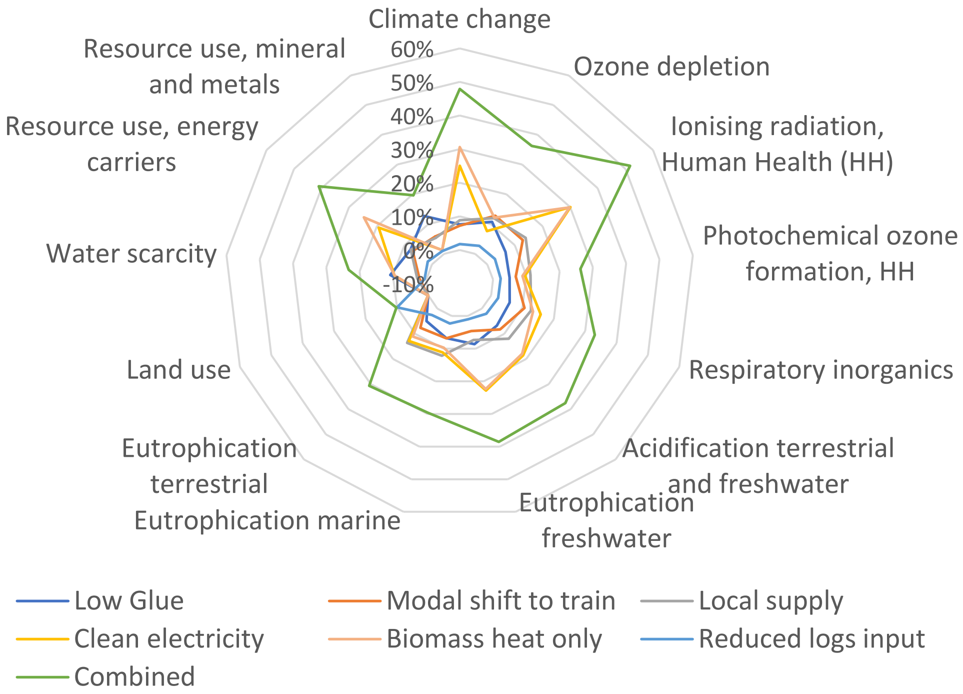

Figure 2. Reduction potentials for different strategies in relation to no action-reference for oriented strand board (OSB), depicted for different environmental impacts.

The results for OSB show that, overall, even with also targeting heat supply, the reduction in environmental impact was not as large as with glulam. The exception was in the category of respiratory inorganics, where OSB had a satisfactory reduction of 33 % for the combination strategy, while glulam had only a 10 % reduction. The most promising strategy for OSB was a shift to clean energy, both electricity (from waterpower) and heat (from biomass).

Strategy no. 1 *Reduce the amount of glue (low glue)* leads to a larger reduction of environmental impact for OSB than for glulam. The reason for this can partially be explained by OSB's use of much more glue than glulam per m^3, such that a 20 % reduction leads to 3.6 kg reduction in glue for OSB but "only" 2.3 kg of glue for glulam.

No. 2, modal shift from heavy-duty vehicle to train, makes sense only for land transport and long distances. A further reduction of the modal shift to train might be reached if all train transport is electrified. This scenario applies the same ratio of diesel train to electric train (ca 50/50) as in the reference situation.

Other strategies to further reduce the environmental impact of OSB and glulam are upstream in forestry, where the building of forest roads and use of wood harvesting machines are believed to have potential. However, this is left for future research.

Even though the percentage reduction is not directly transferable, as the amount of glue, transport length and mode, energy source and wood by-products (cutoffs) are different, the results for OSB and glulam are believed to point in the same direction for other similar engineered products, like particleboard and cross laminated timber.

Downstream, in the production of buildings and furniture, to optimize the use and reuse of materials (minimize waste), material recycling and energy recovery strategies at end of life are believed to be of importance for the life cycle environmental impact of engineered wood products.

The economical cost of different strategies investigated are believed to be responsible; some could even bring a higher profit or cost savings as more environmentally sound wood products goes hand in hand with more efficient transport and production processes and might even be higher priced in the market. However, a financial cost analysis has not been part of this study.

Summary and Conclusions

Different strategies were applied and adjusted in order to improve the environmental profile of engineered wood products, specifically glulam and OSB. With relatively small (e.g., 10 % reduction of wood in production) adjustment, considerable reduction of the environmental impacts of wood products are possible, especially if several strategies are applied and adjusted in combination.

Shifting to clean energy (electricity for glulam and both heat and electricity for OSB) could considerably lower environmental impacts. By combining different strategies, a total reduction of 10 – 61 % for glulam and 10 – 52 % for OSB was achieved. This shows that producers of engineered wood products have a range of strategies available to easily further reduce the life cycle environmental impact of their products. This should be pursued by the wood industry to ease competition with other materials.

Similar research could be done on products from specific geographical regions, as these can be quite different from the global reference made in this contribution. Also, further up in the value chain (e.g. forestry) and further down the life cycle to end of life should be investigated to find further strategies (or parameters) to optimize with the aim of reducing the overall environmental footprint of engineered wood components and their final products.

The results presented here will be used to optimize wooden buildings, for example, to make an environmentally optimized single-family house and compare it to the average European nearly zero-energy building (nZEB) (Schau et al 2019).

Acknowledgements

The author gratefully acknowledges the European Commission for funding InnoRenew CoE (grant agreement #739574), under the H2020 Widespread-Teaming programme, and Republic of Slovenia (investment funding of the Republic of Slovenia and the European Union's European Regional Development Fund).

References

Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., Solazzo, E., Monforti-Ferrario, F., Olivier, J.G.J., Vignati, E., Fossil CO_2 and GHG emissions of all world countries - 2019 Report Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-11100-9, doi:10.2760/687800, JRC117610.

Ecoinvent Centre, 2018, Ecoinvent Life Cycle Inventory Database, v 3.5

European Union (2020) European platform on LCA; Retrieved 27 April 2020 from https://eplca.jrc.ec.europa.eu/

ISO 14040. (2006). Environmental management - Life cycle assessment - Principles and framework. Geneva: International Organization for Standardization.

ISO 14044. (2006). Environmental management - Life cycle assessment - Requirements and guidelines. Geneva: International Organization for Standardization.

Obućina, M., Kitek Kuzman, M., & Sandbeg, D. (2017). Use of sustainable wood building materials in Bosnia and Herzegovina, Slovenia and Sweden. Retrieved 29 May 2020 from http://ltu.diva-portal.org/smash/get/diva2:1140697/FULLTEXT01.pdf

Pré Consultants, 2019, SimaPro Analyst, v. 9.0

Ramage, M. H., Burridge, H., Busse-Wicher, M., Fereday, G., Reynolds, T., et al. (2017). The wood from the trees: The use of timber in construction. *Renewable and Sustainable Energy Reviews*, *68*(Oct. 2015), 333–359. Doi:10.1016/j.rser.2016.09.107

Schau EM, Prelovšek Niemelä E, Niemelä AJ, Alencar Gavric TA and Iztok Šušteršič I (2019) *Life cycle assessment benchmark for wooden buildings in Europe: Single family house - nearly zero-energy building (nZEB)* in The 9th International Conference on Life Cycle Management (LCM2019). Poznan 1-4 Sep 2019 (platform presentation)

United Nations, Department of Economic and Social Affairs, Population Division (2019): World Population Prospect: The 2019 Revision. New York: United Nations.

Annex 1: Characterized results for glued-laminated timber (glulam)

Impact category	Unit	Glulam	Glulam	Glulam	Glulam	Glulam	Glulam	Glulam
		No action (Reference)	Low glue	Modal shift to train	Local supply	Clean electricity	Wood reduction	Combined
Climate change	kg CO_2 eq	2.68E+02	2.57E+02	2.66E+02	2.49E+02	1.47E+02	2.60E+02	1.12E+02
Climate change - fossil	kg CO_2 eq	2.66E+02	2.55E+02	2.64E+02	2.47E+02	1.46E+02	2.57E+02	1.11E+02
Climate change - biogenic	kg CO_2 eq	-1.64E+03	-1.64E+03	-1.64E+03	-1.64E+03	-1.58E+03	-1.48E+03	-1.42E+03
Climate change - biogenic, emissions	kg CO_2 eq	3.26E+02	3.25E+02	3.26E+02	3.25E+02	3.25E+02	3.26E+02	3.24E+02
Climate change - biogenic, uptake	kg CO_2 eq	-1.97E+03	-1.97E+03	-1.97E+03	-1.97E+03	-1.90E+03	-1.80E+03	-1.74E+03
Climate change - land use and transform.	kg CO_2 eq	8.99E-01	8.95E-01	8.94E-01	8.89E-01	6.80E-01	8.40E-01	6.13E-01
Ozone depletion	kg CFC11 eq	2.97E-05	2.80E-05	2.98E-05	2.58E-05	2.43E-05	2.83E-05	1.78E-05
Ionizsing radiation, HH	kBq U-235 eq	1.29E+01	1.25E+01	1.28E+01	1.17E+01	7.12E+00	1.23E+01	5.25E+00
Photochemical ozone formation, HH	kg NMVOC eq	1.63E+00	1.60E+00	1.60E+00	1.49E+00	1.29E+00	1.57E+00	1.08E+00
Respiratory inorganics	disease inc.	8.38E-05	8.26E-05	8.37E-05	8.21E-05	7.86E-05	8.31E-05	7.53E-05
Acidification terrestrial and freshwater	mol H+ eq	1.96E+00	1.88E+00	1.91E+00	1.81E+00	1.33E+00	1.90E+00	1.07E+00
Eutrophication freshwater	kg P eq	1.34E-02	1.28E-02	1.30E-02	1.28E-02	6.68E-03	1.31E-02	5.28E-03
Eutrophication marine	kg N eq	4.99E-01	4.90E-01	4.88E-01	4.54E-01	3.87E-01	4.81E-01	3.23E-01
Eutrophication terrestrial	mol N eq	6.37E+00	6.14E+00	6.25E+00	5.87E+00	5.07E+00	6.17E+00	4.21E+00
Land use	Pt	3.41E+05	3.41E+05	3.41E+05	3.40E+05	2.89E+05	3.10E+05	2.63E+05
Water scarcity	m3 depriv.	1.29E+02	1.10E+02	1.29E+02	1.27E+02	1.11E+02	1.28E+02	8.85E+01
Resource use, energy carriers	MJ	3.67E+03	3.48E+03	3.65E+03	3.39E+03	2.18E+03	3.55E+03	1.64E+03
Resource use, mineral and metals	kg Sb eq	7.06E-04	6.44E-04	7.01E-04	6.53E-04	6.72E-04	6.83E-04	5.41E-04

Annex 2: Characterized results for oriented strand board (OSB)

Impact category	Unit	OSB No action (Reference	OSB Low glue	OSB Modal shift to train	OSB Local supply	OSB Clean electricity	OSB Biomass heat only	OSB Reduced logs input	OSB Combined
Climate change (CC)	kg CO2 eq	3.82E+02	3.53E+02	3.55E+02	3.49E+02	2.86E+02	2.65E+02	3.76E+02	1.99E+02
CC - fossil	kg CO2 eq	3.81E+02	3.52E+02	3.53E+02	3.47E+02	2.85E+02	2.64E+02	3.74E+02	1.98E+02
CC - biogenic	kg CO2 eq	-1.21E+03	-1.21E+03	-1.21E+03	-1.21E+03	-1.21E+03	-1.17E+03	-1.06E+03	-1.01E+03
CC - biogenic, emissions	kg CO2 eq	3.70E+02	3.70E+02	3.70E+02	3.70E+02	3.69E+02	4.16E+02	3.70E+02	4.15E+02
CC - biogenic, uptake	kg CO2 eq	-1.58E+03	-1.58E+03	-1.58E+03	-1.58E+03	-1.58E+03	-1.58E+03	-1.43E+03	-1.42E+03
CC - land use and transform.	kg CO2 eq	8.06E-01	7.84E-01	7.94E-01	7.81E-01	6.61E-01	6.63E-01	7.53E-01	5.66E-01
Ozone depletion	kg CFC11 eq	4.85E-05	4.33E-05	4.23E-05	4.27E-05	4.49E-05	4.26E-05	4.73E-05	3.09E-05
Ionizing radiation, HH	kBq U-235 eq	1.43E+01	1.34E+01	1.25E+01	1.23E+01	1.00E+01	1.00E+01	1.39E+01	6.91E+00
Photochemical ozone formation, HH	kg NMVOC eq	2.51E+00	2.39E+00	2.34E+00	2.23E+00	2.27E+00	2.29E+00	2.45E+00	1.85E+00
Respiratory inorganics	disease inc.	2.28E-05	2.15E-05	2.04E-05	1.99E-05	1.92E-05	1.98E-05	2.23E-05	1.53E-05
Acidification terrestrial and freshwater	mol H+ eq	2.59E+00	2.41E+00	2.38E+00	2.28E+00	2.11E+00	2.12E+00	2.54E+00	1.62E+00
Eutrophication freshwater	kg P eq	2.36E-02	2.16E-02	2.26E-02	2.19E-02	1.82E-02	1.84E-02	2.34E-02	1.45E-02
Eutrophication marine	kg N eq	7.19E-01	6.71E-01	6.70E-01	6.32E-01	6.38E-01	6.49E-01	7.03E-01	5.06E-01
Eutrophication terrestrial	mol N eq	7.24E+00	6.88E+00	6.68E+00	6.25E+00	6.30E+00	6.44E+00	7.06E+00	5.02E+00
Land use	Pt	2.51E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.26E+05	2.25E+05
Water scarcity	m3 depriv.	1.48E+02	1.32E+02	1.45E+02	1.44E+02	1.34E+02	1.34E+02	1.47E+02	1.14E+02
Resource use, energy carriers	MJ	6.00E+03	5.53E+03	5.58E+03	5.54E+03	4.84E+03	4.52E+03	5.91E+03	3.54E+03
Resource use, mineral and metals	kg Sb eq	1.68E-03	1.47E-03	1.58E-03	1.59E-03	1.66E-03	1.66E-03	1.66E-03	1.35E-03