Unlocking the climate potential of Finnish forests

Contents

BeZero

Context and project summary

Stora Enso is building a new headquarters building in Helsinki.
They want to know the positive climate change impacts that the materials chosen have when compared to traditional (grey) solutions.

The headquarters is a four storey building built primarily of Cross Laminated Timber (CLT) and Laminated Veneer Lumber (LVL).

Additionally, there is a further issue to consider: forestry. Both materials chosen for the building are wood materials, so if all new buildings were to be built using those materials, the existent forest would have to produce that wood.

This study analysed three different scenarios for Stora Enso's headquarters building and calculated the GHG emissions savings achieved by using CLT/LVL. The study also analysed Finland's forest cover and calculated the m^3 of timber that could be obtained per hectare, both for North and South Savonia.

Materials innovation: using timber for buildings

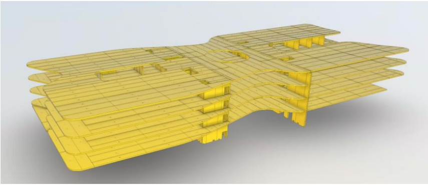
The project:

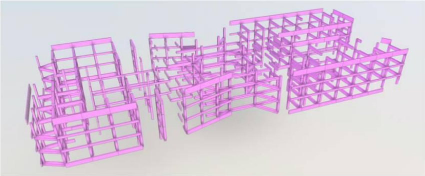
Stora Enso's proposed headquarters in Helsinki is a four storey building built primarily of Cross Laminated Timber (CLT) and Laminated Veneer Lumber (LVL).

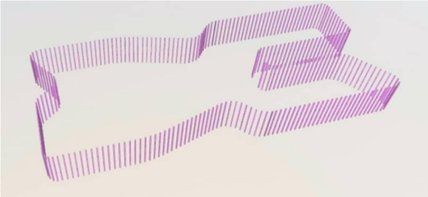
The following study **compares the emissions from a cradle to gate** Life Cycle Assessment (LCA) of the timber tower to **two project scenarios** of the building built in different materials that are more commonly used in the modern architecture typical of the building specifications. The scenarios selected were used a **steel frame or a concrete frame.**

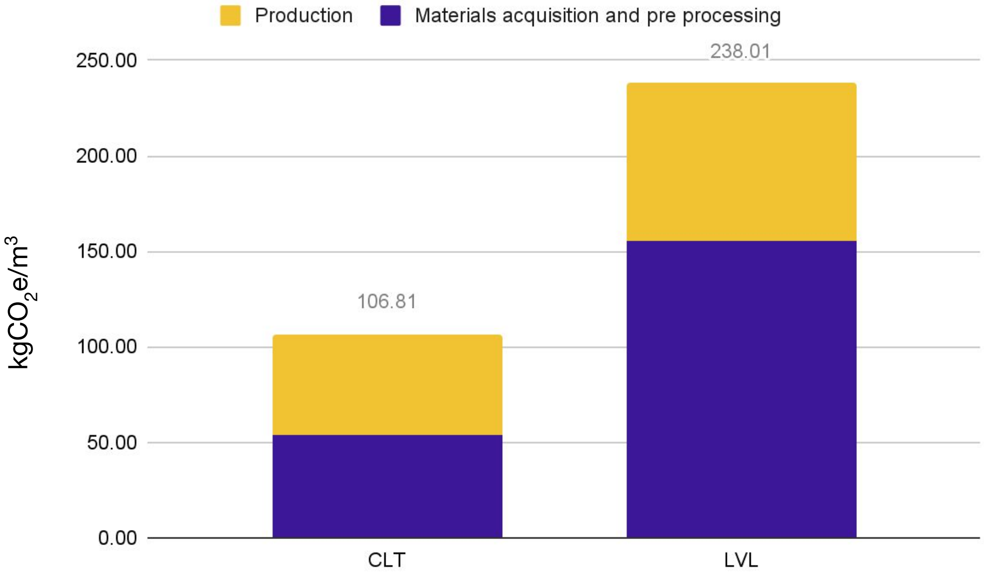
Chosen materials: CLT and LVL

The proposed structure uses a combination CLT (yellow) and LVL (purple). CLT is used for the floors, roofing, internal walls, elevator/technical shafts and stairs; while LVL is used in in a load bearing column and beam system, in addition to elements in the facade system.



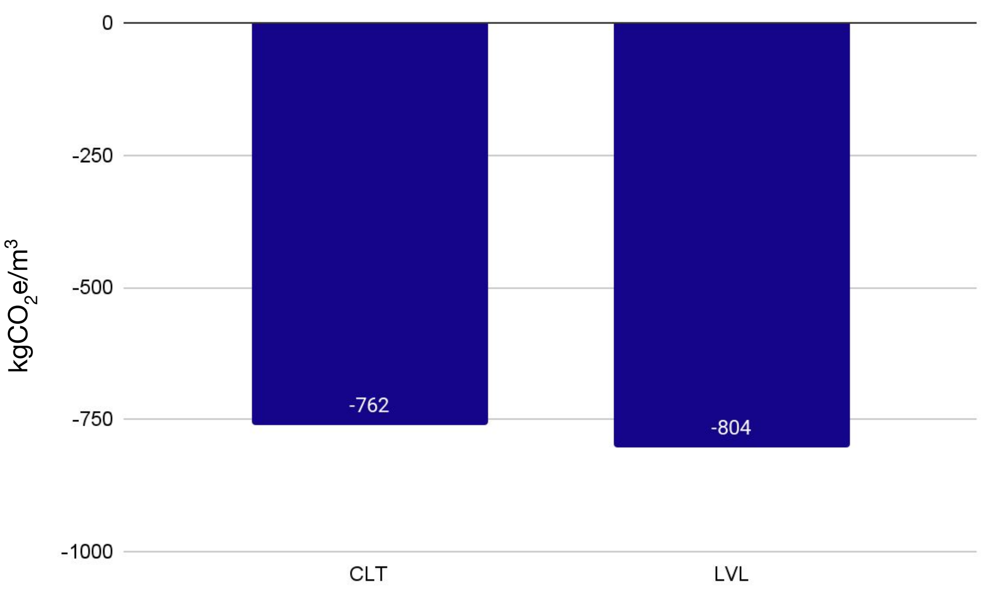






The above graph illustrates the results of the cradle to gate LCAs of CLT and LVL (excluding biogenic emissions). The results show that CLT has the lower impact per m^3 at 107 $kgCO_2e/m^3$, while LVL is higher in both the material acquisition and preprocessing and the production stages (totalling 238 $kgCO_2e/m^3$).

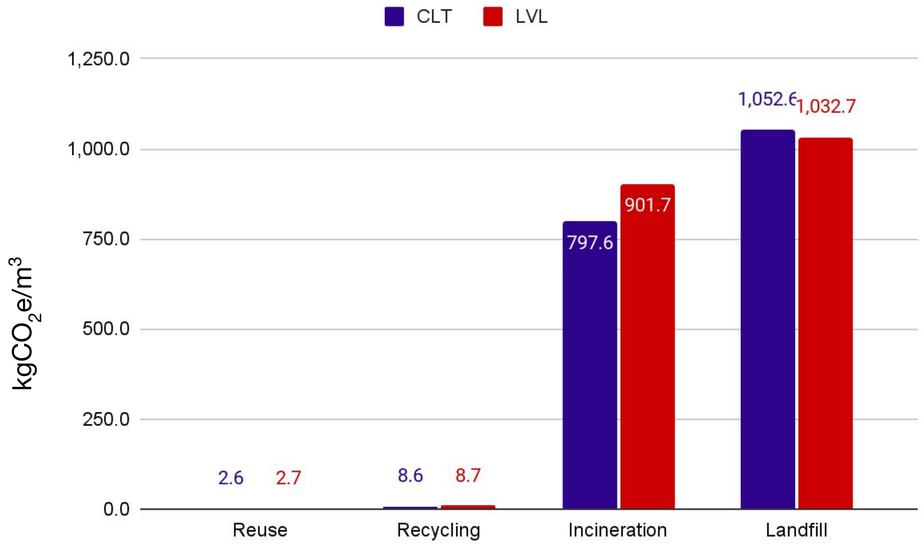
Additional feature: biogenic emissions



Biogenic emissions are -762 $kgCO_2e$ in the CLT and -804 $kgCO_2e$ in the LVL. There are different factors that would be affecting these results, for example, the LVL has a lower percentage of moisture content but a higher density of woody biomass at that percentage.

The biogenic carbon content is not considered in the overall results of this study due to the ambiguity of the end of life treatment, as it cannot be certain that the engineered timber products would be recycled or reused during the end of life and biogenic emissions wouldn't be released during the end of life stage.

End of Life scenarios

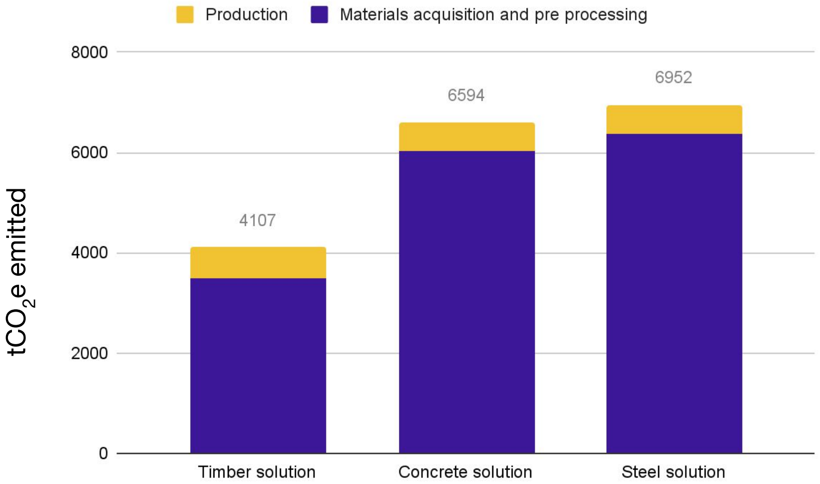


When considering Biogenic emissions, the end of life stage of the material needs to be considered. Both incineration and landfill would re-release the CO_2 stored in the wood products, cancelling out the benefit during the studied building's life cycle. As a result, the **benefits of the stored carbon could only be considered when the wood is reused or recycled.**

In the reuse and recycling scenarios, the continued storage of the biogenic emissions is considered. Further benefits outside the system boundary (such as virgin material replacement) are considered in these results.

The incineration stage returns a low value for the emissions being released while burning due to the consideration of the potential for the material to replace the burning natural gas in heat heat production.

Analysing three different solutions



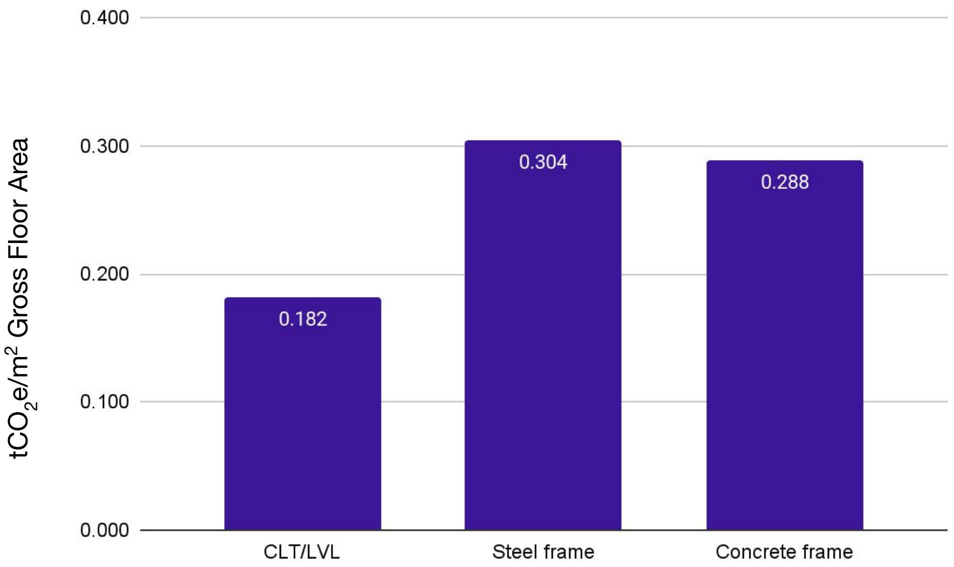
The results show that based on the emissions from the cradle to gate of the material, **the timber solution (CLT/LVL) is by far the lowest carbon solution.** If the biogenic carbon stored in the wood harvested for the product was considered, it would result in a negative value of -895.3 tCO_2e for the materials acquisition and preprocessing and production stages.

The concrete frame solution uses a conceptual building of the same height and floor area as the timber solution.

The steel frame solution was assumed the same as for the concrete study as the closest representative of the actual design.

The cradle to gate results show that concrete has lower embodied emissions than steel, however when taking into account the end of life of each, steel is marginally better than concrete (in this case by about 152.5 tCO_2e) due to its improved potential for recycling.

How does the CLT/LVL building compare to a traditional building?



The comparison materials (steel frame and concrete frame) were selected in order to reflect how the building would have realistically been built as a more typical approach of today's architecture. The material's embodied emissions (graph above) take into account the Cradle to Gate Life Cycle Assessment per m^2 of the gross internal floor area (22,890 m^2).

The results illustrate the **beneficial effects of using engineered timber products** instead of traditional grey solution like concrete and steel. This is due to fewer emissions during the processing phase and assembly of the building. In addition to the results seen above, CLT panels can be disassembled as a unit and reused as is in a new building, reducing the processing needed.

Forest cover analysis

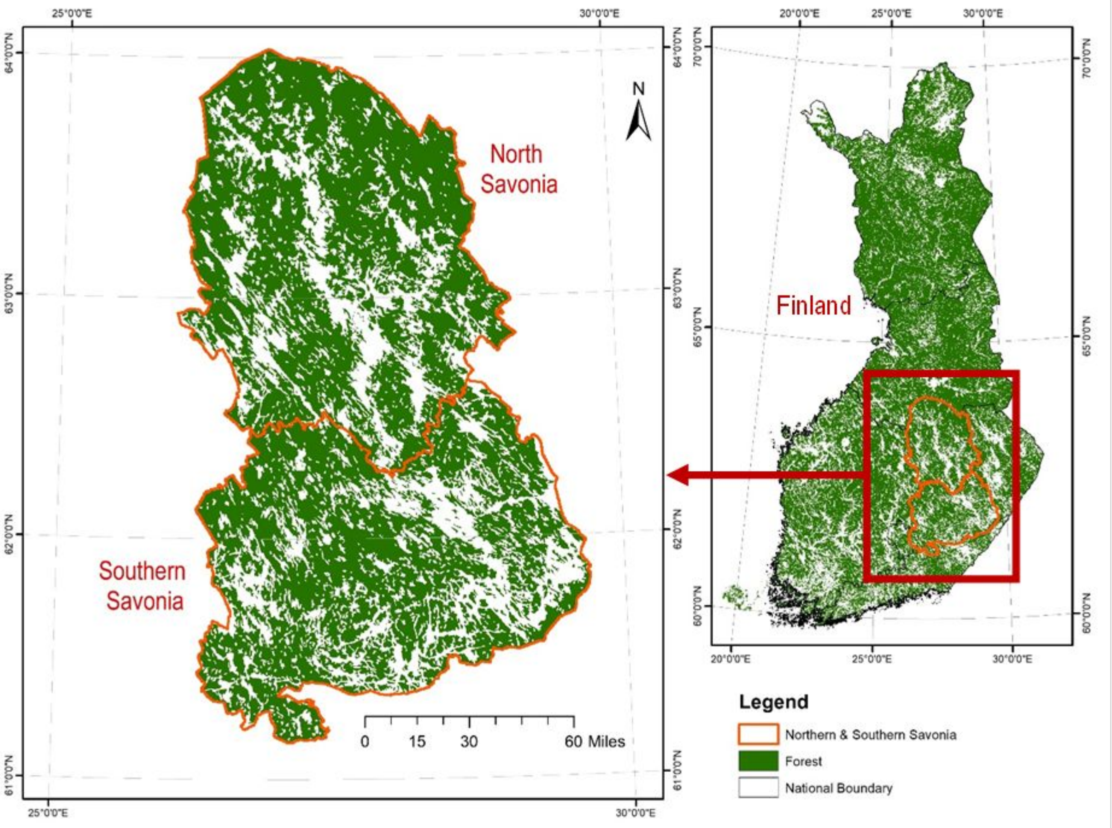
Timber volume estimates from the Forest cover in North/Southern Savonia Province in Finland

The average stock volume of spruce forest at the point of harvesting:

- Northern Savonia (Pohjois-Savo) 314 m^3/ha
- Southern Savonia (Etelä-Savo) 302 m^3/ha.

The total area of North Savonia under forest cover is 1,376, 483 ha and for Southern Savonia is 1,221,465 ha.

Of the total forest cover, the available forest for expected timber production is found on the mineral productive soil which is estimated at 994,291 ha (North Savonia) and 981,959 ha (South Savonia). From the productive forest, the estimated average volumes of timber that can be harvested are 155.8 m^3/ha and 141.9 m^3/ha for South and North Savonia provinces respectively.



Projected Volume of Timber from Productive forest land

The average stock volume of spruce forest at the point of harvesting from productive forest land is:

- Northern Savonia (Pohjois-Savo) 141.9 m^3/ha
- Southern Savonia (Etelä-Savo) 155.8 m^3/ha.

The mean annual increment of growing stock on forest is 6.7 according to the National Forestry Accounting Plan (NFAP, 2018).

The reported annual CO_2 sequestration in Finland was 4.8 $MtCO_2e$/yr.

Area	Forestry area (ha)	Estimated average volume of wood that can be harvested (m^3/ha)	Expected growth by year 30 (i.e. in 2053) (m^3/ha)	Expected Sequestration by year 30 (tCO_2)
North Savonia	994,291	141.9	342.9	4,772,596.8
South Savonia	981,959	155.8	356.8	4,713,403.2

Results

Forestry and Engineered Timber

The following calculations combine the two studies of the forestry and the proposed structure.

The annual national mean volume of the growing stock is 118 m^3/ha and in southern Finland, the mean volume of the growing stock is 143 m^3/ha which is in line with the estimated average for South and North Savonia (155.8 m^3/ha and 141.9 m^3/ha respectively)

The expected harvest in year 2053 is 345,652,678 m^3, from which around 78.5% would be allocated to construction materials (based on 2017 export data of sawnwood and veneer sheets against other timber products for Finland). Taking into account the input of raw material required to manufacture the 1m^3 of CLT and LVL, this would result in a potential 127,481,946 m^3 of engineered timber from the region.

Area	Harvest from 50% of the forest area (ha) in year 2053 (m^3)	Estimated percentage of harvest going to CLT/LVL production	Engineered product that can be manufactured from harvest (m^3 CLT/LVL)
Savonia	345,652,678	78.5%	127,481,946*

*The numbers above have been calculated based on the percentages of CLT vs LVL in the structure and the required input of raw lumber for each m^3 engineered timber manufactured

What would be the impact of using CLT/LVL for new buildings?

Using the calculations for the volumes of product (CLT and LVL) entering the supply chain from the North and South Savonia forestry regions, the table shows the estimated results when applied to the volumes needed to build the current design for the Stora Enso Helsinki building.

Area	Number of CLT/LVL buildings possible	tCO_2e saved by substitution (concrete)	tCO_2 saved by substitution (steel)
Savonia	5,317	151,281,853	132,221,237

Conclusion

The project explored the benefits of using timber in buildings in comparison to grey solutions - namely the benefits of Stora Enso using timber solutions in their proposed headquarters in Helsinki.
The results showed that, for this case study, using engineered timber solutions CLT and LVL in the structure **reduced the emissions by 2,845 tCO_2e in a cradle to gate** study. With the inclusion of biogenic emissions in a cradle to grave study (in which the wood is reused or recycled) the emission reductions would increase by 762 $kgCO_2e/m^3$ material used for CLT and by 804 $kgCO_2e/m^3$.

The **harvestable forestry coverage** in Savonia could support up to **5,317 of the buildings** in this study, **saving up to 151,281,853 tCO_2e** (based on the solutions in this study). Further analysis would be required to understand the current market destination for Savonia's timber harvest and the potential for diversion into engineered timber materials and/or expansion of plantation forest cover.

Appendix

Assumptions

Section	Assumption
General	For closest comparison possible, a building of the same floor area and number of floors as the timber solution is used for the concrete and steel solutions.
Material acquisition and preprocessing (A1-3)	EPDs from Stora Enso for 1m^3 CLT and LVL used.
Production (A4-5)	EPDs from Stora Enso for 1m^3 CLT and LVL used.
Use (B1-7)	N/A
End of Life (C1-4)	N/A
Benefits beyond the system boundary (D)	Not included in the results for either the LCA or end of life treatments due to uncertainty of the treatment.
Forestry and engineered timber	Input to manufacture LVL assumed 1.16 m^3/m^3 Input to manufacture CLT assumed 1 m^3/ 0.43 m^3 The numbers calculated to reflect the amount of the harvest going to engineered timber manufacturing were calculated using values for Finland's export allocation in 2017 taken from FAOSTAT

References

Section	Reference
Forestry	Finnish Forest Research Institute - National Forest Inventory (NFI) Metla: http://www.metla.fi/ohjelma/vmi/vmi-moni-en.htm National Forestry Accounting Plan (NFAP): https://mmm.fi/documents/1410837/1504826/NFAP_Finland_draft+29.11.2018.pdf/df0a7982-030f-35a2-63a8-e003362aa022 State of Finland's Forests - Finnish Forest Research Institute (metla.fi): http://www.metla.fi/metinfo/sustainability/c1-carbon-stock.htm
Materials innovation	Stora Enso EPD 2020: CLT (Cross Laminated Timber) EPD Stora Enso EPD 2019: LVL (Laminated Veneer Lumber) EPD OneClickLCA World's fastest Building Life Cycle Assessment software - One Click LCA 100 CLT projects - Waugh Thistleton Architects Wilson, J. and Dancer, E., 2005. Gate-To-Gate Life-Cycle Inventory Of Laminated Veneer Lumber Production. Wood And Fiber Science, December 2005, V. 37 Corrim Special Issue, pp. 114-127

Our Approach

A Life Cycle Assessment (LCA) approach was used to calculate the emissions related to a cradle to gate life cycle assessment of CLT and LVL. The LCA has two different stages: material acquisition and pre-processing, and production. To illustrate the benefits, we have compared the carbon footprint (tCO_2e/m^3) of the cradle to gate of CLT/LVL, concrete and steel.

Values used in the LCAs are taken from Environmental Product Declarations (EPDs) conducted manufacturers, in line with ISO 14025 and ISO 14044.