Real estate as urban carbon storage

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Wood-based real estate represents remarkable potential for storing carbon removed from the atmosphere by forests, write **Olli Haltia** and **Beata Rantaeskola**

Over the past years, the European market for wood-based construction has been growing at an accelerating pace. The market for mass timber-based real estate is projected to reach €10 billion ($11.3 billion) per annum by 2030, doubling from the current size.

The market is driven by a break-through of new construction materials, especially engineered wood products (EWP) including cross laminated timber (CLT) and laminated veneer lumber (LVL) as well as glulam. EWP construction technologies facilitate versatile solid wood and mass timber structures with strength comparable to steel and concrete and even beyond.

Figure 1. Oodi Library in Finland.

The growing wood-based real estate sector is speedily contributing to 'urban carbon storage'. Althouɡ somewhat novel concept, man-made urban carbon storage performs surprisingly efficiently when coı to various carbon stocks found in nature. In Finland, the accumulated wood material in all buildings currently equals 84 million tonnes carbon dioxide equivalent emissions (mtCO2e), with a growth of 23% over the period of 2000-2016. As a yardstick, the amount of the accumulated carbon thus roughly equals 70% (i.e. 700,000 ha) of the carbon stocked (on-soil) in all Irish forests – Ireland being one of the most dynamic forestry countries in Europe having doubled its forest cover over the past 30 years.

Furthermore, recent research presents a scenario that could see storage of an additional 420 mtCO2e in European wooden buildings by 2040, i.e. more than three times the current CO2 volume of all Irish forests.

From a life cycle viewpoint, there are at least two interesting questions to investigate regarding wood-based construction. First, how does a mass timber building differ from a viewpoint of climate performance - especially as a carbon store – compared to a typical concrete building?

Second, keeping in mind that wood is a renewable material grown by forests, how does the life cycle performance of a wood-based construction change when the biological growth of a forest is taken into account in the calculation?

For the first question, Figure 2 illustrates a comparative life cycle analysis of wood- and concrete-based apartment buildings. The analysis compares two practically identical six-floor apartment buildings – the only difference being the main construction material, i.e. wood versus concrete. For both buildings, the heating is based on geothermal energy; the consumption of energy and insulation is assumed to be equal. Figure 2 identifies the initial carbon storage for the CLT and concrete buildings (columns for Storage CLT, Storage Concrete, respectively) as measured in terms of kg CO2e per gross area. Since CLT is essentially a solid wood product and thus formed by carbon, the carbon storage of a CLT building by far exceeds the one of a concrete building.

"An investment portfolio optimally managed for climate change mitigation includes wood-based real estate, in addition to timberland"

It does not matter what the construction material is; energy is required in various forms during the life cycle of a building, implying in practise atmospheric emissions. To start with, carbon is emitted in the manufacturing of the building materials. The process of manufacturing concrete is of course intensive in carbon, but some emissions are also incurred in the fabrication of CLT, although on a relatively minor scale. Moreover, further carbon is emitted during the construction, use and repair of the building.

Such emissions represent annual flows of carbon to the atmosphere over the life cycle of a building. Calculating cumulating emissions over the life cycle, it is interesting to look at an evolution of a "carbon balance" or the "net storage after emissions".

So, what is the net carbon storage of a building when the cumulative emissions are considered? Here, a carbon emission is counted as "consuming" the initial carbon storage, resulting in a net carbon storage after emissions. As discussed above, carbon emissions are, firstly, formed by the raw material sourcing, transport, and manufacturing of the product. For wood, the trees have been logged, transported to a mill, and manufactured into CLT. Moreover, concrete foundations are required also for a wooden apartment building – in the analysis, we assume that the first floor of the CLT-apartment building is made of concrete.

As indicated by Figure 2, the carbon emissions of the raw materials for CLT buildings are not insignificant, clearly reducing the climate performance of a wood-based construction. However, such raw material related emissions are even larger for a concrete building, resulting in a negative carbon storage in net terms. With wood, material-related emissions are estimated at about 40% smaller.

Figure 2. Life cycle analysis of carbon storage for CLT-based building vs concrete building, Net Carbon Storage after accumulated emissions (kg CO2e/m2, 50-year calculation period).

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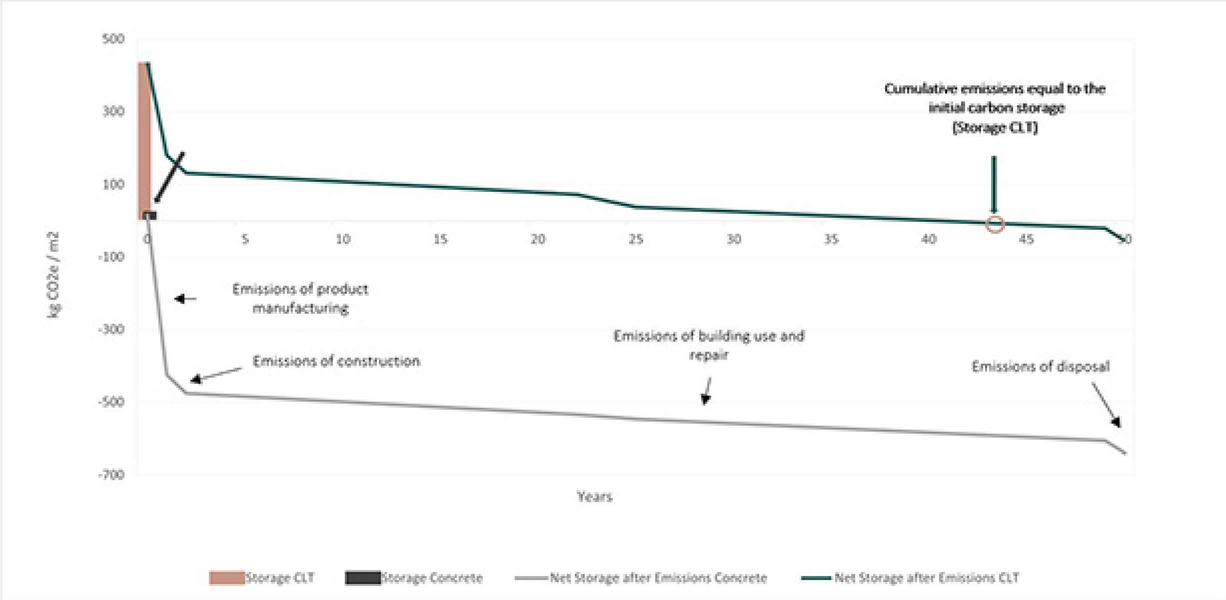

Source: Dasos Capital.

It is especially due to the emissions arising in the context of concrete manufacturing that a concrete building has fundamentally carbon negative performance.

Second, further emissions are generated with the construction phase in the building's lifecycle. Thereafter, emissions are associated with the use and repair of a building. Finally, material disposal is assumed for both building types at the end of the period, also implying emissions. However, it is good to note that the possibilities for reusing untreated wood are very wide. The CLT structure can be moved to a new construction site at the end of the building's life, even without modification. This important link has been completely left out of the calculation. It has been assumed that for both materials the disposal means waste. The reuse of CLT/wood could further significantly improve the carbon balance of a wooden building.

The CLT building will remain a carbon store in net terms (Net Storage after Emissions CLT) until year 43 in the scenario. Depending on the exact time of repair, the range for the break-even is 39 to 46 years. At this point, the accumulated emissions over the life cycle have grown equal to the carbon storage of the building. It is only after 43 years that the CLT-building will have a negative atmospheric effect in terms of CO2 balance.

We next explore the carbon balance of a CLT building by extending the life cycle analysis to take account the re-growth of forest. The re-growth denotes for the biological growth of the forest on the area required for harvesting of the wood volume for the CLT consumed per m2 in the building. Such a calculation is somewhat sensitive to technical parameters as well as, for example, to the assumed rate of the biological growth.

To be conservative regarding the regenerative process of a forest we assume in a base scenario that harvesting amounts to 100 m3/ha (average over all harvesting methods extending from thinnings, continuous growing, clear cutting, to shelterwood felling) and that the biological growth is at 5 m3/ha/a – which are parameters corresponding to forestry practise some 300km north from the south coast of Finland. Further to the south, harvesting per ha tends to be higher whilst the forest growth would exceed our base assumption.

As illustrated in Figure 3, the re-growth of forest will quickly start to store carbon (Forest Re-Growth), offsetting the effect of emissions. After a few years' decline of the net carbon storage due to emissions, the biological growth will exceed the negative effect of the emissions and net storage starts to increase (Forest Re-Growth + Net Storage CLT).

Figure 3. Life cycle analysis of Carbon Storage for CLT-based building with Forest Re-Growth, kg CO2e/m2.

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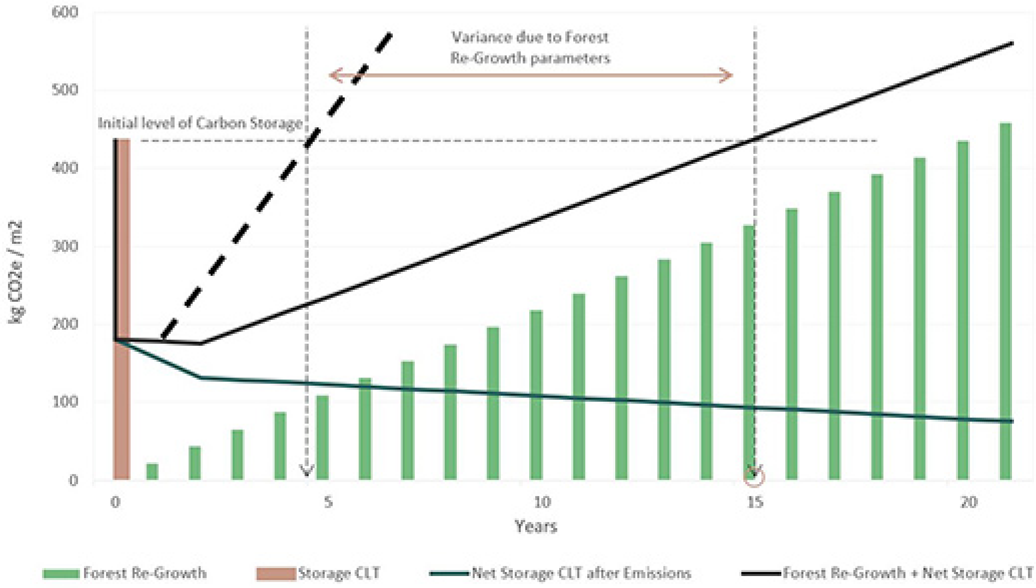

Source: Dasos Capital.

The initial level of the carbon storage is achieved in 15 years in our base case. Assuming more optimistic technical and biological parameters, the recovery time of the carbon storage is perhaps only four to five years. Thus, a wooden house would remain a carbon store when the regenerative process of the forest is included in the analysis. The harvested area grows back the harvested amount of CO2, compensating rapidly the negative effect due to emissions from the raw material, construction, use, repair, and disposal necessary for a wooden building.

In fact, such an urban carbon store, being maintained in walls, floors, and ceilings of a house, may be considered more permanent storage than a standing stock in a forest. It should be noted that forest is exposed to aging and risks related to insects, diseases, wind, and fire. Thus, it should be attractive to store part of the atmospheric carbon captured by biological growth of forests into wooden buildings in the context of a sustainable climate-smart forestry and development of the low-carbon construction sector.

Figure 4. The Finnish Nature Centre Haltia has a CLT structure.

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In summary, wood-based real estate forms potentially an increasingly important urban carbon store. Such storage is complementary to the CO2 stock of forests and is not exposed to similar 'natural' risks as wood standing in a forest. The scope for urban carbon storage represents an opportunity to diversify away from risks inherent with forest-based CO2 management. Hence, an investment portfolio optimally managed for climate change mitigation includes wood-based real estate, in addition to timberland.

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