CARBON STORAGE IN WOOD-BASED BUILDINGS

It all begins with photosynthesis

Our planet has natural mechanisms to keep the amount of carbon dioxide (CO_2) at the optimal level for its present flora and fauna. The most important of these mechanisms include the carbon flows in seas, soils and living plants. In photosynthesis, plants sequester carbon (C) atoms from the atmosphere and convert them into sugars. Only sunlight and water are needed for fuelling this transformation. As a result, oxygen (O) is released into the atmosphere and carbon stays in the biomass of plants until they naturally decompose.

Because of photosynthesis, the dry mass of wood is 50% carbon[1]. The significance of this carbon is that it is taken away from the atmosphere and thus it is away from contributing to the greenhouse effect. This makes atmospheric carbon different to the carbons made from fossil resources. They come from the earth´s crust and exacerbate the greenhouse effect if released into the atmosphere.

Forests need to be treated with care so that they can play their vital role in global carbon cycles. European forests grow more than they are harvested. Their carbon stores have grown for decades and with the current harvesting rate of 60%, they sequester around 10% of all European greenhouse gas emissions[2]. This potential can be further increased with the help of fertilisation and liming. Because of the unique role of forests in regulating atmospheric CO_2 content and providing renewable raw-materials, forest-based construction products may have a minimal or even negative carbon footprint in their production phase[3].

The timely importance of carbon sequestration

The high environmental, economic and social risks of climate change have led many leading scientists[4] and institutions[5,6] to demand the fast phase-out of fossil fuels and to reduce greenhouse gas emissions. The built environment is accountable for around 30% of all greenhouse gas emissions[7] and therefore has a vital role in the mitigation of climate change. First, ambitious energy efficiency plans have been made and, for example, after 2020, all new buildings in the EU have to consume practically no energy at all [8]. Simultaneously, there are planned reductions in the carbon intensity of energy. As a result of these improvements, the emissions from the production phase of buildings starts to play larger role than those emissions arising over the full life cycle of a building[9].

Once released, CO_2 continues to warm the atmosphere for hundreds of years. Therefore, it seems that making energy efficient buildings is not enough for mitigating climate change, if they are made from materials that cause large CO_2 emissions during their production[10]. Amortising the emissions from the production of zero energy buildings may take decades. Due to the acute need to cut down greenhouse gas emissions, we cannot afford to wait so long.

The relevance of buildings as carbon stores

While planning any new building or renovating an existing one, we should from now on always look at the emissions caused by the production of construction materials. Wood-based materials can be used in most parts of a building to reduce its carbon footprint and for storing atmospheric carbon. This inherent property enables designers and builders to reach ambitious CO_2 mitigation goals by realising buildings that not only have high energy efficiency but also minimum emissions in the production phase.

Let´s take an example: a passive house was designed for the cold Finnish climate with two alternative construction material combinations: a wood frame with wood-fibre insulation and an aircrete frame with EPS insulation. Both options gave the building´s shell the same level of energy efficiency, but the emissions from the production of the alternative frames were significantly different. The wooden alternative caused approximately 40% less CO_2 emissions[11]. In addition, it was also a great store of atmospheric carbon. Figure 1 illustrates these differences. Wood-based walls, roofs and floors are good building parts for storing atmospheric carbon. The size of this store in the wood-framed alternative is almost four times as much as in the alternative example.

A study[12] of alternative construction materials for energy efficient urban apartments gave interesting findings about the potential for storing carbon in different parts of the building. When different material combinations were compared, wooden building components were found to provide carbon storage for all buildings regardless of their frame, insulation and cladding materials. When the wooden frame was used however, carbon storage was around twice as much as the emissions during the production of all their materials. Figure 2 shows the amount of carbon storage in different material combinations.

How can we unleash the potential of carbon storage over the life cycle of a building?

All materials have their pros and cons. Wood, however, may play the important role of lowering the carbon footprint of all buildings.

The largest potential for storing carbon can be achieved in external walls, intermediate floors and roof structures. If these parts are made with wooden frames, there is the opportunity to reduce the carbon footprint of the building considerably. Figure 3 shows CO_2 emissions and carbon storage in different building parts of eight European buildings[13]. For instance, using Kerto LVL columns and floor elements gave a four-storey timber building a large carbon storage of 204 kg / m^2 of floor area[14]. The carbon footprint of Kerto LVL is actually negative: 1m^3 of the product has a global warming potential of -655 kg CO_2e, because large quantities of biogenic carbon are stored in the spruce wood[15].

Because large amounts of carbon can be stored in the wooden parts of buildings, it is important to ensure that they will stay in the building as long as possible. Long service life requires good design, moisture safety during the construction period and maintaining the building well. Maintenance can be seen to preserve not only the monetary and functional values of the building, but also as a good deed against climate change.

After wooden building parts are no longer used, they may be reused or recycled into other products. This way the atmospheric carbon will stay locked away and not contribute to the greenhouse effect. At the end of a cascade of recycling, wooden parts can be burnt as carbon neutral bioenergy to replace fossil fuels. Even this is not the end of the story. Carbon returns into the atmosphere and is re-captured by growing, sustainably managed forests. The remaining ashes can be used as fertiliser that boosts carbon sequestration by promoting tree growth in forests[16] or a substitute for cement that lowers the carbon footprint of concrete[17].

Renewable revolution

Given the unique properties of wood, we should take advantage of its potential as a store of carbon in all types of buildings. If buildings were re-invented in today´s world that struggles with both climate change and resource scarcity, they would likely be made of mostly renewable materials. Taking steps towards such a renewable revolution is possible with the help of well-developed building products that demonstrably reduce impacts on the environment. The rest is up to designers and builders.

FIGURES

Note: these are drafts that need to be re-drawn for publishing.

FIGURE 1. Differences in the carbon footprint and carbon storage of the same passive house designed with different frame and insulation materials. Source: Aalto University / Matti Kuittinen.

FIGURE 2. The potential of carbon stored in different material alternatives of the same townhouse. Source: Aalto University / Atsushi Takano.

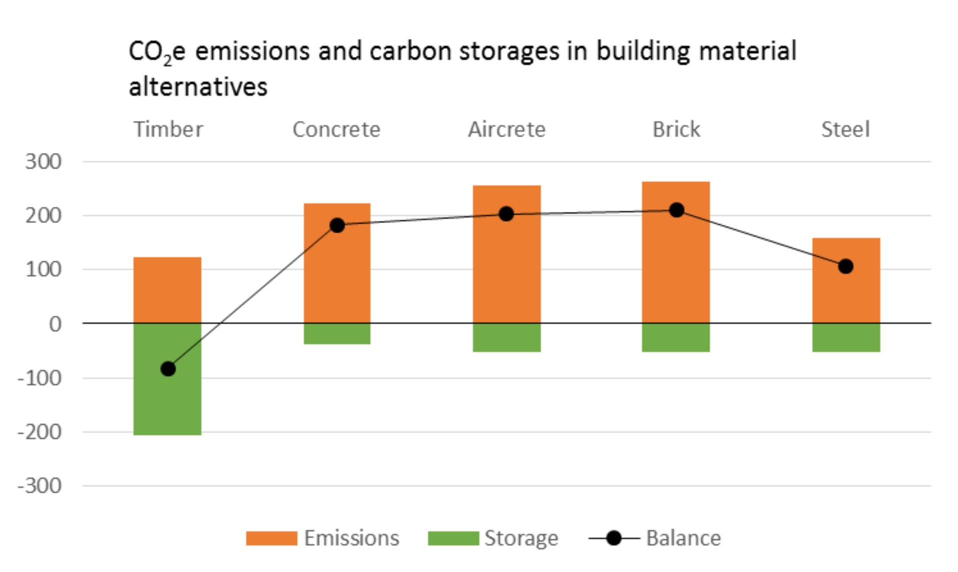
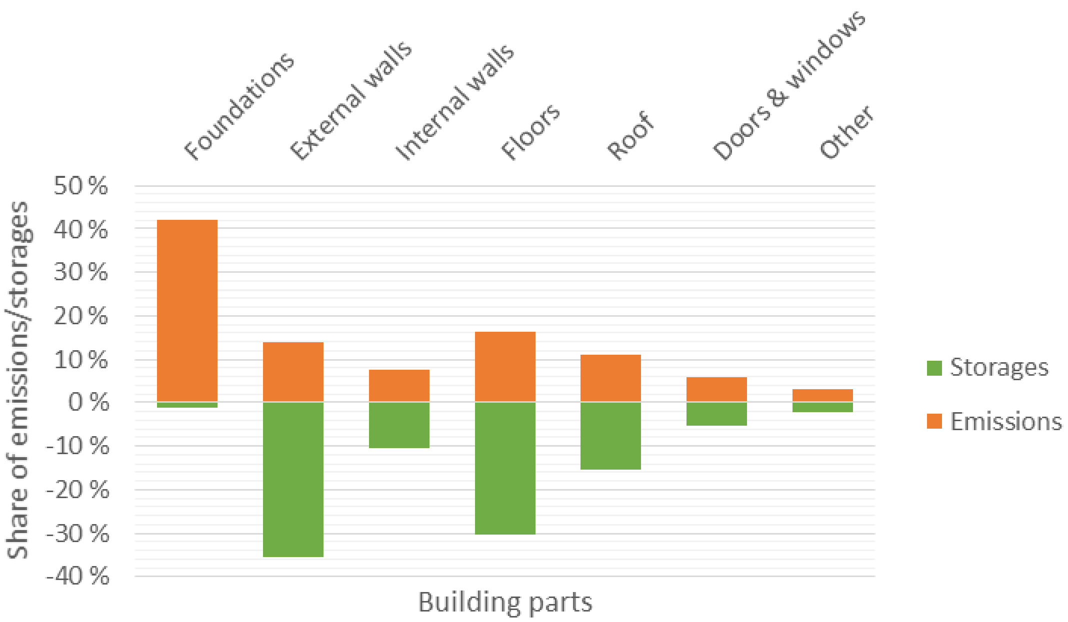


FIGURE 3. The average CO_2 emissions and carbon storage in various parts of six new wood-framed buildings. Source: Aalto University / Matti Kuittinen.



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FOR BACKGROUND INFORMATION ONLY, WILL BE LEFT OUT FROM THE PUBLISHED ARTICLE

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