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CO₂ sequestration potential of log homes

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CO₂ sequestration potential of log homes

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Abstract. Beside the reduction of greenhouse gas emission the adsorption and bounding of carbon dioxide is also an important issue to protect the environment from irreversible harms. By photosynthesis produced wood material mostly built up from the CO₂ content of the atmosphere and it is stored until burning or natural decay of the material. Log homes sequester significant amount of wood for longer time and the amount in cubic meter and the carbon dioxide equivalence were examined in this case study. Wood content of 80 log homes were investigated and the average of 35.28 m³ was found. The average stored carbon dioxide per log homes was 31 tons, and there is slight difference between one and two storied buildings 0.214 and 0.284 tons of equivalent carbon dioxide per layout square meter respectively. The ceiling height influences the wood content of the building significantly and the variation is higher in the case of two-storied buildings.

1. Introduction

The International Climate Change Community (ICCC) has identified forests as crucial sinks for offsetting atmospheric CO₂. To stop the growth of greenhouse gases, it is a good way to increase the quantity of wood products from sustainable sources which will increase the demand for timber production and consequently the afforestation and reforestation processes. Nowadays various studies analyzed the opportunities that how carbon emission can be reduced. Through the whole lifecycle of building the operating phase is the larger CO₂ emission part, including the heating, ventilation and air-conditioning energy against the CO₂ emissions during building and demolition. Of course the CO₂ emitted during construction phase is not negligible. To reduce carbon dioxide emissions during the construction phase, one of the possible solutions is to use environmentally friendly building materials [1]. While other materials (e.g.: concrete, bricks, cement, plastic) have high equivalent carbon-emissions during manufacturing, the wood based building materials have the lowest embodied energy and therefore the lowest carbon emission [2]. Moreover log homes has good atmosphere inside, no harmful emissions and lower heating energy demands. On the other hand, during the formation of wood, atmospheric carbon dioxide is incorporated into the wood for a long time [3-6]. The built-in wood material stores significant amount of carbon, because of about 50 weight percent of the wood is carbon. Consequently the more wood is built-in to buildings the more is the mitigation of climate change supposed to be reforested the area the wood were harvested. Usually the planned life cycle of residential buildings is 50 years, however this period can be more times longer in case of log buildings store the carbon for centuries. There are mountain regions with three or four hundred year old houses without any damage caused by the years.

The aim of this investigation was to define the amount of wood content in a log home in the relation to the size of the building and determine the equivalent carbon dioxide amount the building stores during its life cycle. The investigation relates only solid residential wood wall buildings and do not considered wood frame buildings or weekend houses.

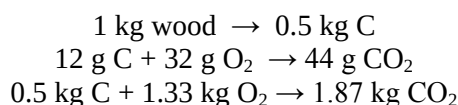


2. Materials and methods

In this case study the calculations were carried out on the architectural plans of 80 real log homes were built in the past or was building at the time of the investigation. The building plan data come from the archives of more log home building companies or from the working table in case the actually built houses. All building was residential homes built either in Hungary or the region of Mid Europe. Only technical data of the buildings were processed without any harm of personal right. The most important data concerning this study were the integrated wall surfaces and the thickness of the wall. Both data could be read from floor plans and the cross section of the building. The surfaces of windows and doors were deducted from the total surface of the walls. The inside walls were also counted without the door surfaces. The integrated wall volume was counted in each house and the calculation made by the wood data described below.

The bases of the calculations were given by the wooden log thickness and the surface of wall, but it was also considered the ceilings and wooden frame of the insulation fixing and the façade siding, and slabs. Doors and windows were not included in the calculations. Due to the variety of slabs, they were simplified and based on the most common type, and standard cross section was calculated. High ratio of the buildings had rectangular shape wall elements, but there were some with cylindrical cross section. The case of cylindrical logs the equivalent cross section was calculated and the data were used as to be transformed to a rectangular shape. When the building had an attic then the real wall height was counted even if the height was different, and the upstands were included to the calculation. In every case the real wood amount was calculated and the less approximation was used as possible. The roof contains significant amount of wood, though the roof of the brick buildings is mostly made of wood also the purpose of the study was to determine the wood content of log homes and not finding the difference to other type of buildings. The materials of doors and windows were not able to diagnose on the plan that is the first reason were not calculated, the other reason the variety of door windows profiles and cross sections which would have made cause high uncertainty in the calculation. The counted wood amount result data was related to the net living area of the building.

In Europe, spruce (*Picea abies*) is the most popular construction wood [7]. The companies provide the plan data used mostly spruce wood species and only few cases shows different wood species such as larch and scots pine that is why the calculation had been run for spruce. Knowing the average density of spruce 470 kg/m³ [8] in the case of moisture content of 12% and the volume of walls, the weight of the walls can be calculated. Researches have shown that the carbon content of wood species in most cases is between 46 and 55% [9-10]. Therefore, in the different calculations usually 50% carbon content is used [11-13]. The calculated amount of carbon can convert to amount of CO₂, which is bounded from the air.



500 kg carbon bounded in wood body means around 1870 kg carbon dioxide abstraction from the air. It can be calculated from the molecule weights of the molecules. In other words 1870 kg CO₂ is necessary to be deprived from the atmosphere to build around 1 ton of wood.

3. Results and discussion

The examined 80 buildings contain 8886 m² built-in living area, and the used total amount of wood was 2822.51 m³, representing 2480.7 tons of carbon dioxide. These log houses have an average floor area of 111 m² and 35.28 m³ wood is consumed which means 31 tons carbon dioxide for an average log home.

Based on these results 0.3176 m³ of timber is needed to 1 m² of living space construction, which represents an average 0.279 tons of atmospheric CO₂ for every built in square meter.

The results were plotted as a function of the floor area Figure 1. Houses with a larger floor area are made of more wood and thus store more CO₂, but the relationship between the floor space and the

amount of CO₂ sequestered is not linear. Theoretically the trend looks similar than that of a saturation curve. The saturation curve is an exponential function with the equation (1).

$$y = 0.6147 \cdot x^{0.7999} \quad (1)$$

The 'x' means the floor area of the building and 'y' is the stored CO₂ amount.

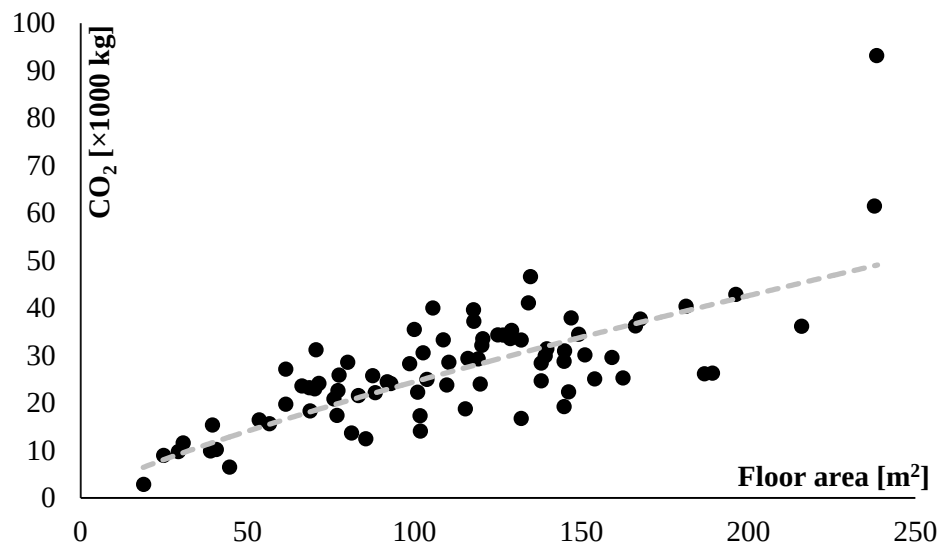


Figure 1 The amount of CO₂ sequestered in the examined wooden houses as a function of the floor area

If the one and two-storied buildings are examined separately, it is striking that the dispersion of the amount of sequestered CO₂ in one-storied buildings is smaller Figure 2-3. This is due to the fact that while the single-story buildings have only a slight change of ceiling height, the height of the upstands is more varied on the two-story buildings. In case of one-storied buildings 0.284 tons of CO₂ is sequestered in 1 m² of living space, while this value is 0.214 tons for the two storied buildings.

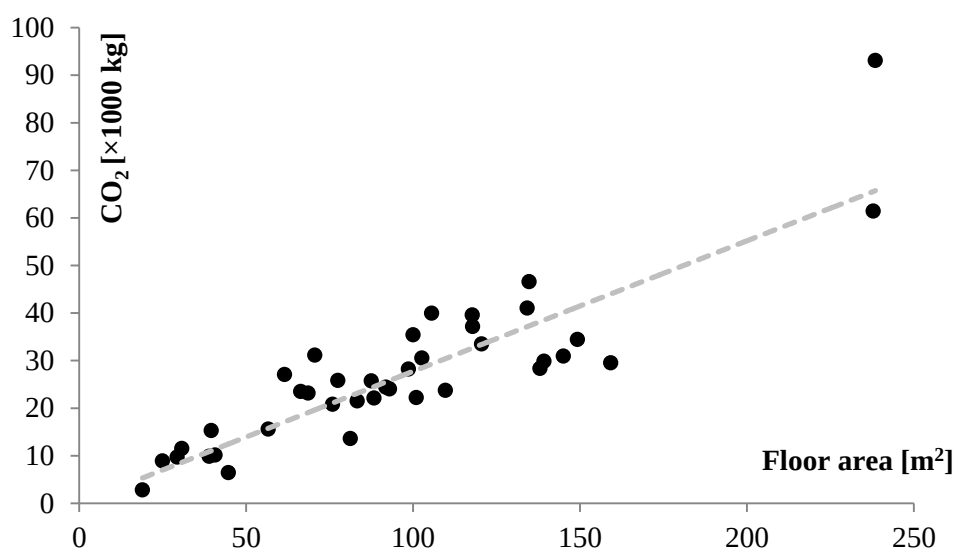


Figure 2 The amount of CO₂ sequestered in the examined wooden houses as a function of the floor area in case of the one-storied buildings

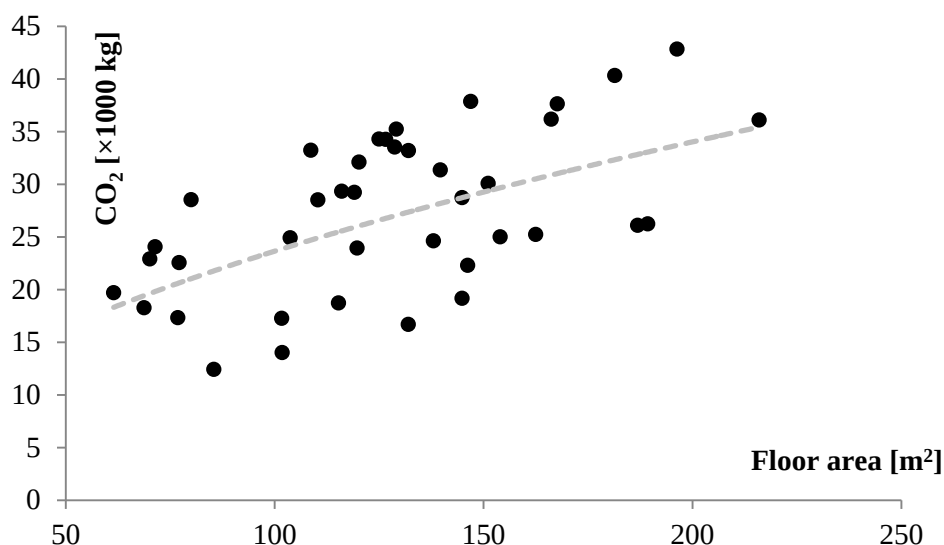


Figure 3 The amount of CO₂ sequestered in the examined wooden houses as a function of the floor area in case of the two-storied buildings

4. Conclusion

Comparing buildings in terms of environmental awareness has been more actual than ever before. The investigation of 80 log homes results an average data of 31 tons of stored carbon dioxide each building which was bonded in 35.28 m³ wood materials. Carbon dioxide concerning to the square meter of the building provides a comparison of the one-storied (0.284 ton) and two storied buildings (0.214 ton). The ceiling height affects considerable the wood amount of the building. The variety of ceiling height is much smaller in single story buildings than that of the two story buildings.

The log homes store very high amount of carbon dioxide coming from the atmosphere against other building type such as brick or concrete buildings. From the aspects of environment protection using and producing more wood in a sustainable way is one of the possible fighting weapon against global warming. Beside this important fact the atmosphere in the wooden house can be more comfortable and healthier than other type of buildings. Sustaining development is the key of our future, so to carry out more research would be useful.

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