Methodological description – CO_2 emissions from the use of forest biomass for energy production

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The harvesting of forest biomass affects forest carbon stocks. Increased harvesting of forest biomass reduces the amount of carbon stored in forests. This loss of carbon stock is dynamic and particularly dependent on the types of biomass harvested and the period of time during which the impact is reviewed (Helin et al. 2013). In terms of the production of forest bioenergy, the loss of carbon stock means that there is less carbon in the forest and more CO_2 in the atmosphere. Therefore, the loss of carbon stock can be regarded as an indirect emission (Pingoud et al. 2016).

According to international accounting and reporting rules for greenhouse gases, the CO_2 balance of biomass is determined by changes in stock instead of flows entering or exiting the atmosphere. Therefore, the CO_2 emissions from burning biomass are calculated and reported as zero in the energy sector. In harvesting forest biomass, the carbon extracted from the forest is considered an emission in the “managed forest land” category reported for the land use, land-use change and forestry (LULUCF) sector. The total GHG balance of managed forest land is the difference of GHGs stored in the biomass of trees, forest litter and the soil and CO_2 and other GHGs released from the soil and by the harvesting of forest biomass. Some of the carbon harvested from the forest is temporarily stored in harvested wood products (HWPs) and the increase of their carbon stock is calculated and reported as GHG removal.

The next section describes the determination of CO_2 emissions resulting from the use of forest harvest residues and stemwood for energy production.

Emissions caused by the use of forest harvest residues for energy production

The calculation of CO_2 emissions caused by the use of forest harvest residues is based on indirect CO_2 emissions created when the carbon stored in forest harvest residues is directly released into the atmosphere as CO_2 in the combustion reaction of the biomass instead of having the residues slowly decay in the harvested area (Repo et al. 2011). The decay time of forest harvest residues in terms of branches (crown mass) and stumps was calculated on the basis of the Yasso07 model’s average spruce results from Southern and Northern Finland (Liski et al. 2011) as a function of time for 100 years.

Emissions caused by the use of stemwood for energy production

The calculation of CO_2 emissions caused by first thinning, commercial thinning and final felling is based on a situation where the thinning or felling is carried out and the obtained stemwood is burned in a bioenergy plant instead of leaving the trees to grow in the forest. In terms of thinning and the final felling, the calculations are based on simulations prepared for conditions in Southern Finland using the MOTTI model (Hynynen et al. 2002; Matala et al. 2003; Salminen et al. 2005), comparing the impact of the first five years of first thinning, commercial thinning or final felling on the carbon stock of the forest over a 100-year period of review with a situation where said thinning or final felling is not carried out (Helin et al. 2016). The development of carbon in standing tree stocks is based on growth curves of MOTTI model (Hynynen et al. 2002; Matala et al. 2003; Salminen et al. 2005) and in the case of unharvested forest manually increased natural mortality of trees.

Results of the calculator system

The system calculates the indirect CO_2 caused by forest harvest residues and the harvesting of commercial timber over the selected time frame by comparing the amount of carbon stored in the forest harvest residues left to decay in the forest and/or in the stemwood left to grow in the forest with a situation where the forest

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harvest residues and/or stemwood are harvested for bioenergy and the carbon is released into the atmosphere as CO_2 in the year of harvesting.

The results yield a cumulative loss of carbon stock in the forest as calculated over the period under review, the average annual loss of carbon stock in the forest over the period under review, the cumulative loss of carbon stock in the forest calculated per the amount of carbon and the energy content in the harvested wood and the annual reduction of carbon stock in the forest as a result of harvesting as a function of time.

The cumulative loss of carbon stock at the end of the selected period under review is calculated on the basis of the annual harvesting volume, shares of the types of harvested biomass, the length of the harvesting period and the lentgh of the period under review as selected in the calculator system. The length of the harvesting period determines the number of consecutive years on which the biomass is harvested with the selected harvesting volume and shares of the types of biomass, whereas the length of the period under review determines the period of observing the changes in the carbon stock of the forest.

Consecutive annual harvesting of forest biomass accumulates the loss of carbon stock. The longer the harvesting period under review, the higher the accumulation of the loss of carbon stock. The length of the period under review impacts the loss of carbon stock accumulated by different types of biomass in different ways. The loss of carbon stock accumulated by forest harvest residues and thinnings is reduced as the period under review increases. This stems from the fact that forest harvest residues decay over time when left to forest and the growth of trees is boosted in thinned forest compared to unthinned forest. In terms of timber harvested in final felling, the accumulating loss of carbon stock initially increased due to the increment loss and the reduction of carbon stock in the soil caused by the harvesting in the first decades, compared to a situation where the timber is not harvested (Helin et al. 2016). The cumulative loss of carbon stock is reduced as the new tree stand growing in the harvested area reaches a carbon sequestration capacity that is greater than in a situation where the final felling is not carried out.

The calculator system yields the graph “Loss of carbon stock in the forest as function of time” based on the principles and simulations above. The graph displays the impact of using timber for energy production on the carbon stock of forests as function of time. This can be used to examine the volume of the loss of carbon stock in forests as a consequence of harvesting forest biomass in a specific year. The annual loss of carbon stock can be compared with annual emissions or the total carbon sink of forests, for example.

Default values in the calculator system

- Forest harvest residues consist of spruce with a 2 cm diameter of the branches (crown mass) and a 30 cm diameter of the stumps (Liski et al. 2011)
- One cubic metre (m^3) of harvested biomass contains 0.2 tonnes of carbon (t C) (Alakangas et al. 2016)
- One cubic metre of harvested biomass contains 0.4 tonnes of dry matter (Alakangas et al. 2016)
- Energy content of dry wood matter: 19.25 GJ per one tonne of dry matter (Alakangas et al. 2016)

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