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# Model analysis of alternative $CO_2$ emission coefficients of solid biomass

**Here we present a set of energy-system model results based on the assumption that the use of solid biomass for energy purposes is related to net emissions of $CO_2$. This is in contrast to traditional assumptions and energy systems modelling where the emission coefficient of biomass, generally, is zero. Based on other research work, we have used alternative emission coefficients of solid biomass within a range of 100-200 kg $CO_2$/MWh and compared the model outcome to the default assumption of 0 kg $CO_2$/MWh. Given ambitious climate ambitions towards 2050, this would imply a relatively limited effect in the Nordic countries in terms of biomass use for energy supply. However, since a carbon cost would be added also to biomass in such a scenario, total costs of biomass would increase. This, in turn, would affect costs and prices of e.g. district heating.**

## The objective of the study

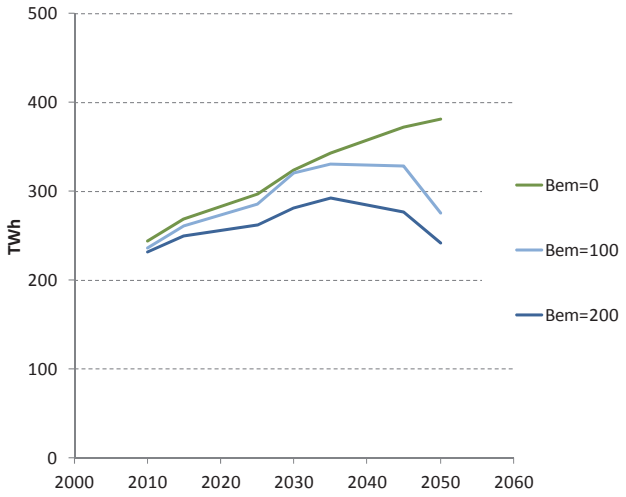
Whether the combustion of biomass leads to net greenhouse-gas emissions or not is subject to constant debate also within the research community. It is not the purpose of this study to advocate for either side. We can, however, conclude that energy-systems modelling almost exclusively use greenhouse-gas emission coefficients of zero, based on the assumptions made by e.g. IPCC. Yet, in some cases upstream emissions, through the use of fossil fuels for supplying biomass fuels, are also included in the analysis implying that emission factors could be larger than zero also in "traditional" analyses. In the present analysis, however, the objective is to assess the impact on the long-term development of the energy system in case that the incineration of biomass itself is considered to generate net $CO_2$ emissions. This means that the use of biomass would be associated with an emission coefficient larger than zero. In the context of the European emission-trading scheme, the EU ETS, this would, thus, add a carbon cost to the use of biomass for energy supply. This is in a sense subject to political decisions and such discussions have been held by e.g. the European Commission.

The choice of an alternative emission coefficient of biomass is based on research made by the Swedish Environmental research Institute, IVL. In this study, we have investigated the effect of using three different emission coefficients of solid biomass: 200 kg $CO_2$/MWh ("stumps"), 100 kg $CO_2$/MWh ("GROT") and 0 kg $CO_2$/MWh. The first one, 200 kg/MWh, is likely to be considered as rather extreme. The second one, 100 kg/MWh is the upper end of a range between 50-100 kg/MWh valid for branches and tops. The third one, zero, is our default option. Thus, the alternative emission coefficients have deliberately been chosen as relatively high based on the research by IVL. Thereby, the model analysis takes on a somewhat of a "worst case" assessment. "Non"-solid biomass such as biogas and waste liquors in the pulp and paper industry are, however, related to zero emissions in all investigated cases.

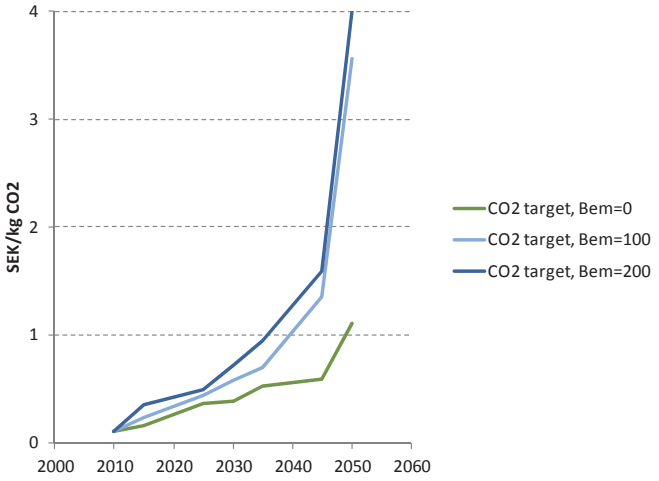
For the model analysis, we have used the MARKAL-NORDIC model including the entire stationary energy system, i.e. excluding transportation, of the four Nordic countries Sweden, Norway, Denmark and Finland. Furthermore, the electricity-supply systems of Germany and Poland are included. The time horizon stretches to 2050. Three emission factors of solid biomass in the Nordic countries have been investigated. This has been done for a given $CO_2$-emission reduction target applied to the region in focus. Emissions are linearly reduced by approximately 60 percent by 2050 compared to emissions in 2010.

## The demand for biomass will continue to grow

If solid biomass were to be assigned with emission coefficients larger than zero, this will have an impact on the future demand for biomass for any given climate target. If the emissions coefficient is set to zero, i.e. the default case, demand for biomass is rapidly growing up to approximately 350 TWh by 2030 in the Nordic




*Demand for biomass in the Nordic countries (stationary energy systems) for the three investigated cases.*




*Marginal abatement cost of $CO_2$ in the Nordic countries for the given $CO_2$ target and the three alternative emission coefficients of solid biomass*

countries. If, on the other hand, the emission coefficient of solid biomass is set to 200 kg/MWh, the demand for biomass is significantly lower, around 250 TWh in a long-term perspective. Using 100 kg/MWh as emission coefficient implies little difference from the default case up until 2030. After that, demand decreases.

In the case where the emission coefficient is set to 200 kg/MWh, solid biomass has the same climate properties as natural gas. Even though climate targets are ambitious there is still a demand for biomass (and natural gas) in order to meet the demands for energy services. Furthermore, it is assumed here that renewable policy instruments such as electricity certificates in Sweden and Norway still support the use of biomass for electricity generation (as well as other means of producing renewable electricity) even though biomass combustion is related to net $CO_2$ emissions in two of our model runs. A parallel to this is the existing situation for peat in Sweden. On one hand, peat combustion for electricity generation benefits from support through the electricity-certificate scheme. On the other hand, peat combustion is subject to carbon costs through the EU ETS scheme.

## $CO_2$ emissions for biomass would increase abatement cost significantly

Since we have applied a $CO_2$ target to the system, marginal costs of $CO_2$ abatement are obtained as model results. In the default case (zero as emission coefficient for solid biomass), marginal abatement costs are less than 0,4 SEK/kg $CO_2$ until 2030. As we approach 2050, marginal costs continue to rise and reach 1 SEK/kg $CO_2$. Once again, this assumes that the Nordic countries jointly reduce their $CO_2$ emissions from the stationary energy system by 60 percent by 2050. If we, however, assign emission coefficients larger than zero to the incineration of solid biomass, marginal costs of $CO_2$ abatement increase significantly. Thus, climate policy (for the same given reduction target) has become more expensive since one of the major energy carriers in the Nordic countries, solid biomass, is considered a net contributor to anthropogenic greenhouse-gas emissions.

## Electricity generation from biomass only marginally smaller

Even though the use of solid biomass is associated with net $CO_2$ emissions in two of our three investigated cases, solid biomass is still considered as a renewable fuel. Thus, the use of biomass benefits, regardless of the choice of $CO_2$-emission coefficient, from renewable energy policy instruments such as the Swedish-Norwegian electricity scheme. Even though we concluded above that solid biomass unilaterally reduces its competitiveness towards other renewable energy carriers such as wind power, our model calculations indicate that this would have little impact within the Swedish-Norwegian electricity-certificate scheme. In the “worst outcome” for biomass, i.e. 200 kg/MWh, the electricity generation based on biomass in 2020 would be around 2 TWh lower compared to our default case (zero net emissions from solid biomass). Accordingly, since the electricity-certificate target is given and fixed, wind power would generate around 2 TWh more. This is relatively small compared to the total volumes of biomass-based electricity generation, around 12 TWh, that are expected to be generated within the electricity-certificate scheme.

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