

Lorie Hamelin

Carbon Management and Environmental Consequences of Agricultural Biomass in a Danish Renewable Energy Strategy

Popular abstract

The Danish Government has set a long term ambition for Denmark to be independent of fossil fuels in 2050. To this end, biomass is an indispensable resource, because 1) it is storable and 2) it is a major source of carbon, a resource that becomes limited in a world without fossil fuels. This PhD work studied, through life cycle assessments, the environmental consequences of using biomass within a renewable energy system in Denmark. Three biomass types stemming from the agricultural sector were particularly investigated: energy crops (i.e. crops grown specifically for being used as an energy source), manure and straw. Food waste (from household or stores) and garden waste have also been investigated. The main findings of this PhD study were that:

- Avoiding conventional manure management through diverting the manure for biogas production yields tremendous environmental benefits. For this reason, a renewable energy strategy should include a maximum of manure-based biogas;
- Straw and biowastes (i.e. garden waste and food waste from household and stores) should be prioritized as co-substrates for manure biogas, rather than being used for combustion or compost. In fact, using these biomasses for enhancing the amount of biogas produced from manure-biogas yielded greater environmental benefits, allowed a better recycling of the nutrients and slowly degradable carbon, and, most importantly, enables the production of a storable gas that can be used for both heat & power production, transport, or the synthesis of carbon material/chemicals. Such flexibility was shown to be a key asset for a renewable energy system involving more than 50% wind power, such as the one Denmark aims for;
- Energy crops, because they involve competition for the use of worlds' limited suitable land for cultivation, should be used as a last priority within a renewable energy system. This PhD work demonstrated that such competition lead to a certain share of conversion of virgin lands to agricultural land, which in turn involves a high environmental cost, especially with respect to global warming. However, to the extent that energy crops are needed, it was shown that long duration perennial crops, particularly *Miscanthus* and willow, should be favored.
- Winter wheat was highlighted as the only annual crop where straw removal for bioenergy may be suitable, being the only annual crop not involving losses of soil organic carbon as a result of harvesting the straw. This, however, was only true for sandy soils, and was conditional to manure application. On this basis, and in the light of on-going work on assessing the quality of Danish soils, straw removal should preferably take place on soils with low clay-to-soil organic matter ratio.
- Finally, it was pointed out that, in a renewable energy future, biomass will become the main source of carbon. In this respect, it was emphasized that carbon efficiency of future biomass & technology combinations will be a decisive concern in a fossil free society.