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The “Upfront carbon debt of bioenergy” study: is bioenergy carbon neutral ?

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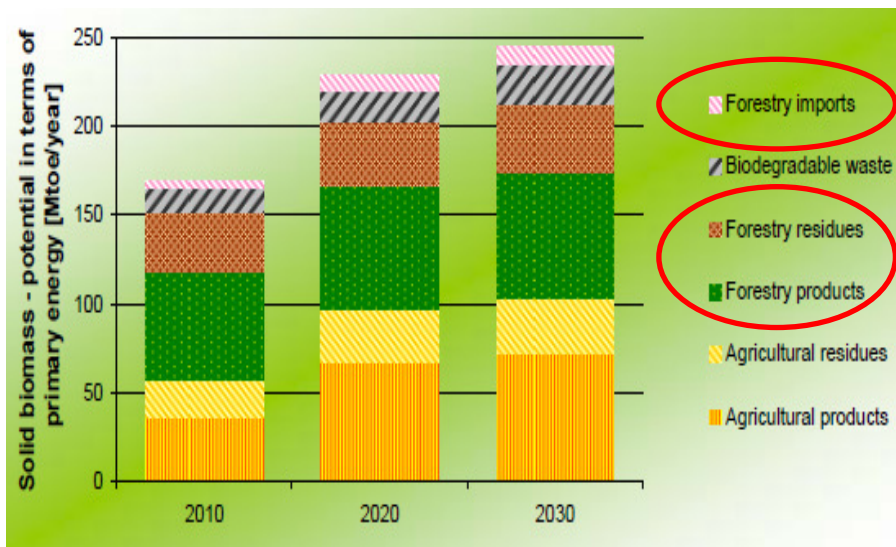
Conference “Sustainable Biomass for European Energy”, Brussels 29 November 2010

Rationale

Bioenergy is meant to **substitute** fossil fuels

Does bioenergy reduce GHG emissions **compared** to fossil fuels?

Projections of bioenergy deployment to meet EU targets (Ragwitz *et al.* 2009):

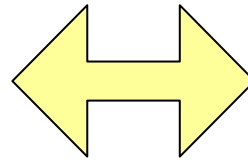


2020:

Solid biomass and biowaste = 58% of total RES generation (140 Mtoe of 240 Mtoe)

A comparative method

Emissions produced
by the bioenergy
system



Emissions produced
by the fossil fuel
system

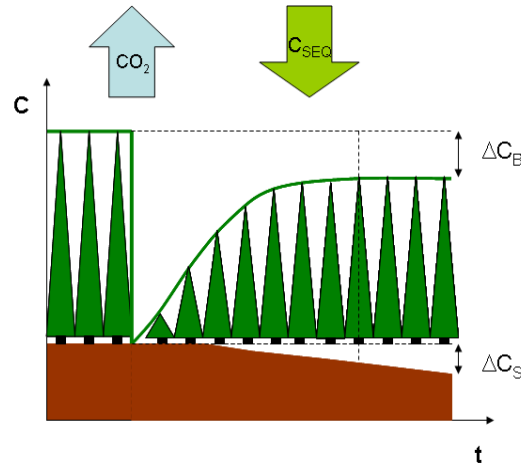
- Production chain emissions (production, conversion, transportation,...)
- **Emissions from stock change = “*stock emissions*” (fossil fuel stock vs. biomass stock)**

The comparison is ***over time*** (forward baseline) on cumulative emissions

→ Different to inventory systems that detect changes compared to a fix point in time (past baseline)

“Stock emissions”

Bioenergy system



Fossil fuel system



- **Annual crops:** emission and sequestration occur within **one year**; stock emissions = 0
- Increased biomass extraction from **forests**: there is a time delay of **several decades** between emission and sequestration; *stock emissions* change over time
- **Fossil fuels:** it can be assumed that **no sequestration** occurs; *stock emissions* = amount of burnt fossil fuel

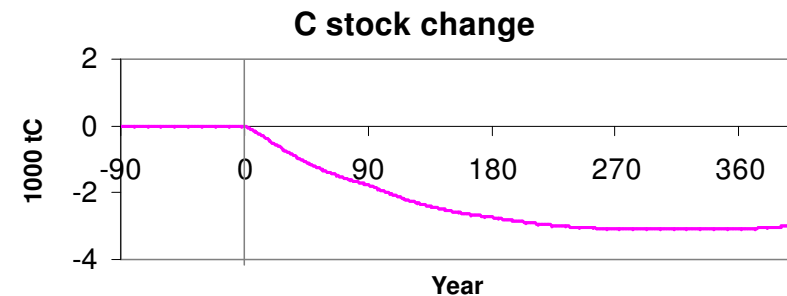
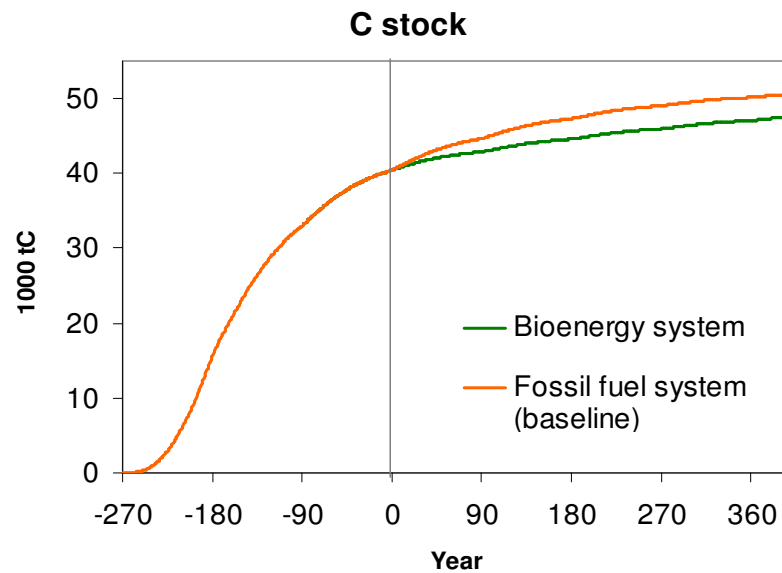
Step 1: *Stock emissions* of woody bioenergy

How are bioenergy *stock emissions* calculated?

Difference of biomass C stock (forest + products) between:

- the bioenergy system
- the fossil fuel system (no bioenergy extraction)

→ Carbon stock change (tC) is converted to CO₂

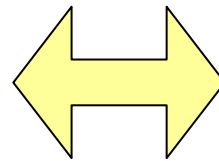


Higher increment under more intensive management can partially compensate the initial loss of C stock

Step 2: Comparison to cumulative fossil fuel *stock emissions*

At a certain point in time t :

Bioenergy
stock emissions

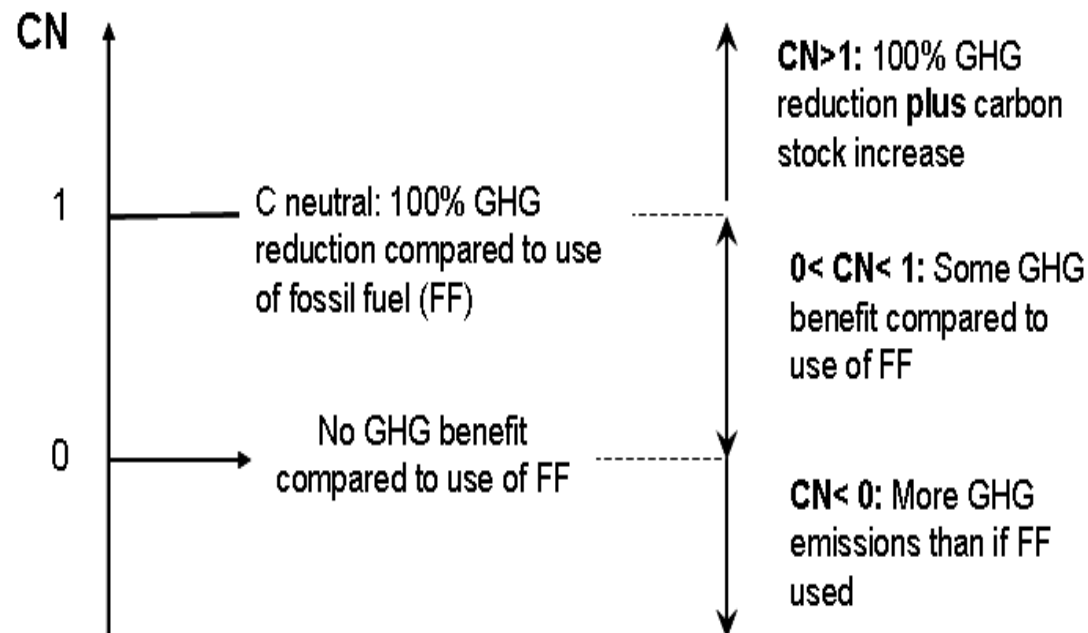


Cumulative
amount of burnt
fossil fuel

Step 3: Comparison expressed as a ratio

Carbon Neutrality factor (CN): quantifies the extent to which the use of bioenergy reduces GHG emission compared to fossil fuel **over time** (Schlamadinger and Spitzer 1994):

$$CN(t) = \frac{E_{FF}(t) - E_B(t)}{E_{FF}(t)} = 1 - \frac{E_B(t)}{E_{FF}(t)}$$



Illustrative case studies

The impact of *stock emissions* (→ GHG profile) changes according to the source of biomass

Examples:

1. Additional fellings from a managed forest
2. Felling residues from a managed forest
3. Change of final use (different products)
4. New plantations

Illustrative case studies

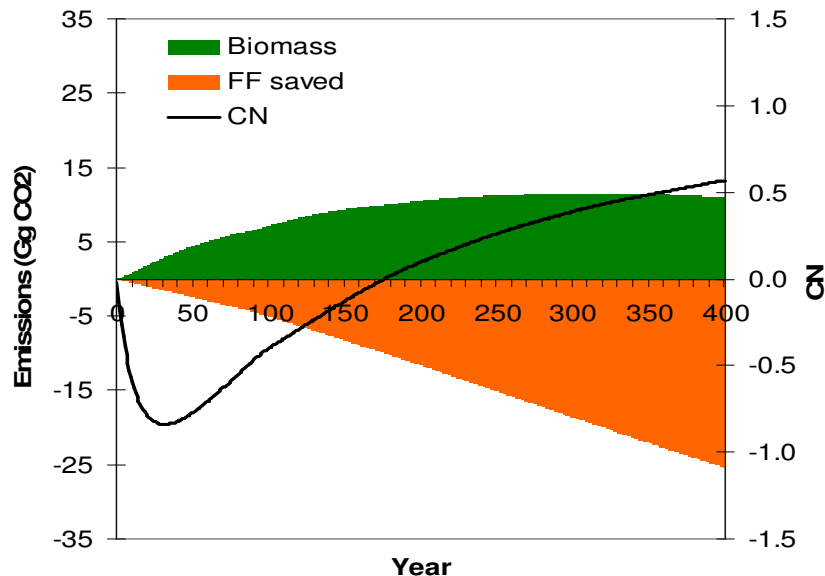
Model: GORCAM

Growth curve

$$\Delta B = \frac{B_{i-1}R}{N} \left[1 - \left(\frac{B_{i-1}}{B_{\max}} \right)^N \right]$$

Yield table: Spruce, Austria

Graph of results



- Biomass *stock emissions* (green)
- Fossil fuel *stock emissions* (orange, represented as savings)
- CN factor (black line)

1. Additional fellings from a managed forest (1)

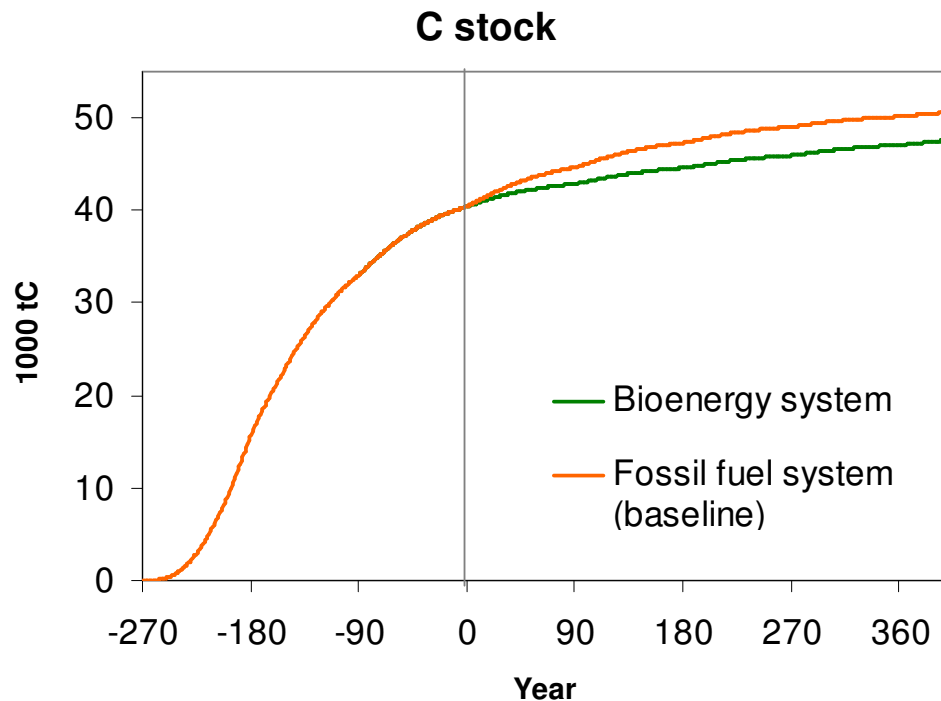
Rotation period: 90 years
Rotation forest: 90 hectares

Harvesting:

a) Baseline: 60% of increment

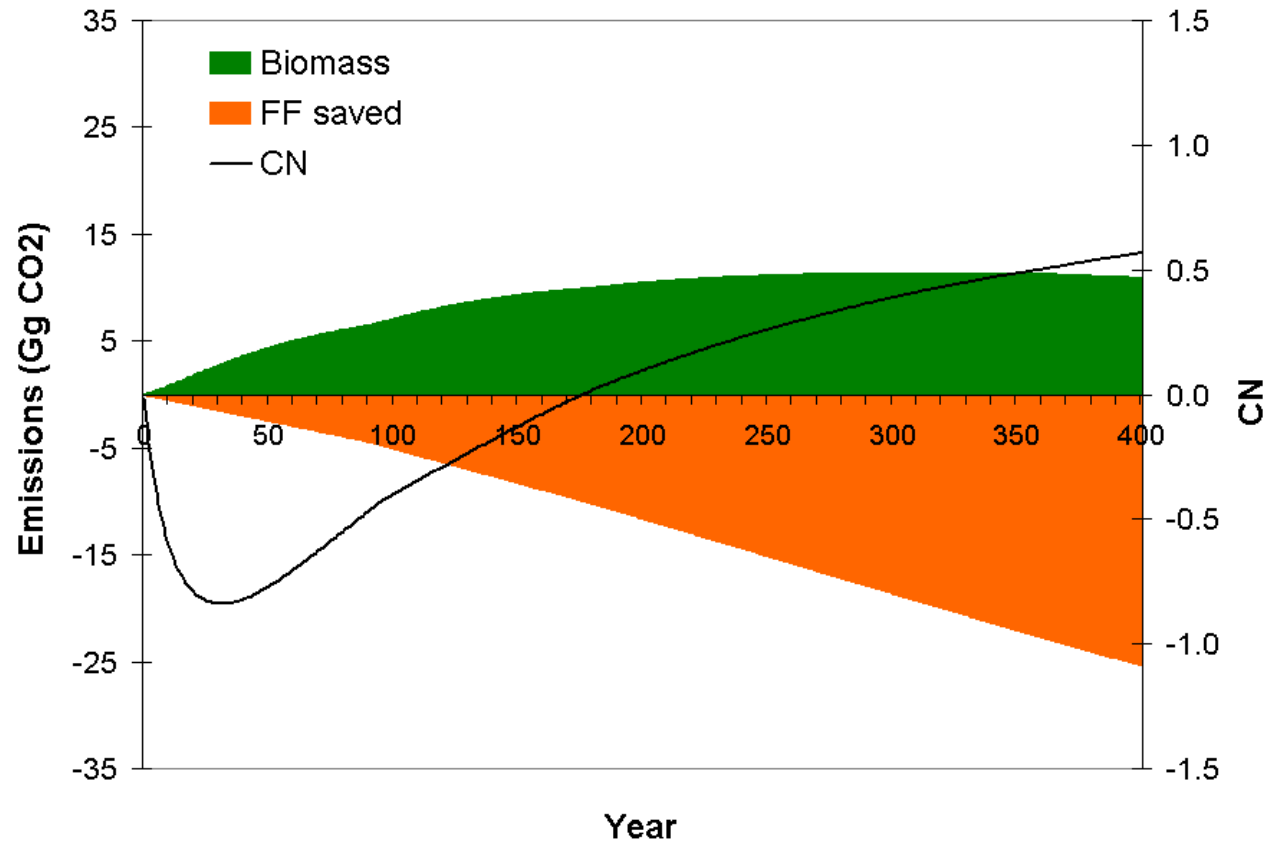
b) New Management: 80% of increment

The additional biomass is used for bioenergy



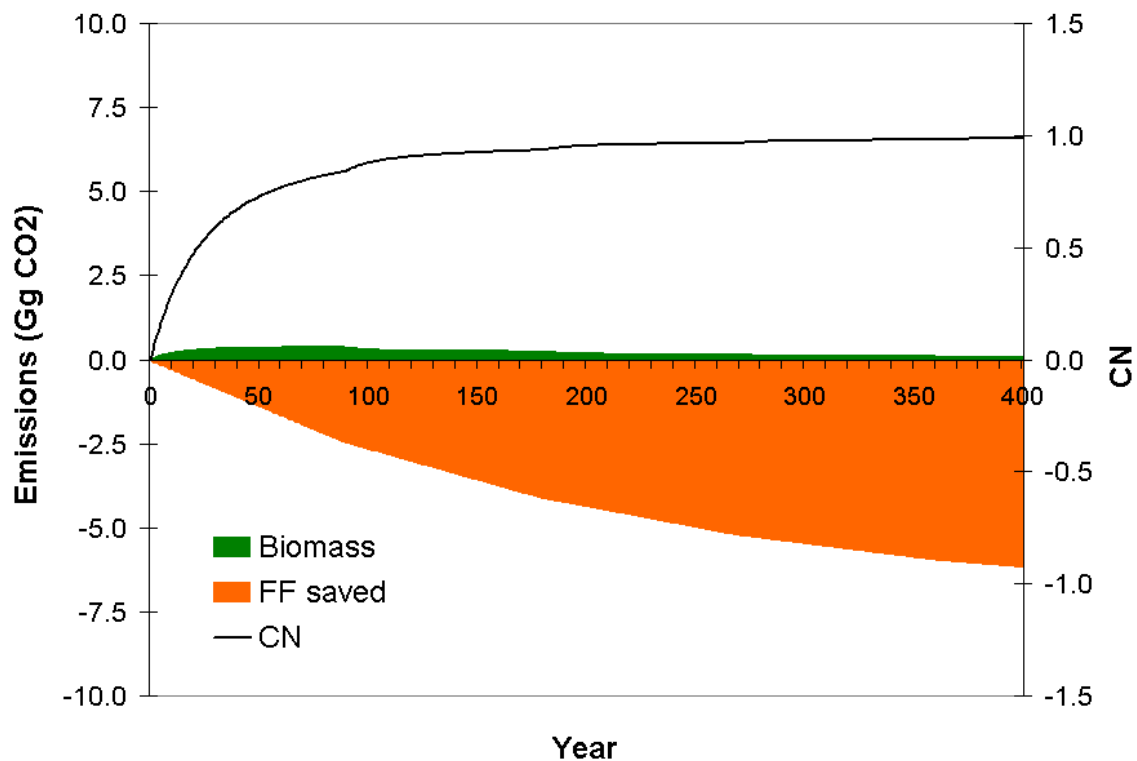
1. Additional fellings from a managed forest (2)

Comparison of cumulative *stock emissions* → CN factor



2. Felling residues from a managed forest

- Rotation period: 90 years (→90 ha)
- Harvest is 60% of the increment
- Baseline: woody litter left in the forest
- New Management: woody litter to bioenergy

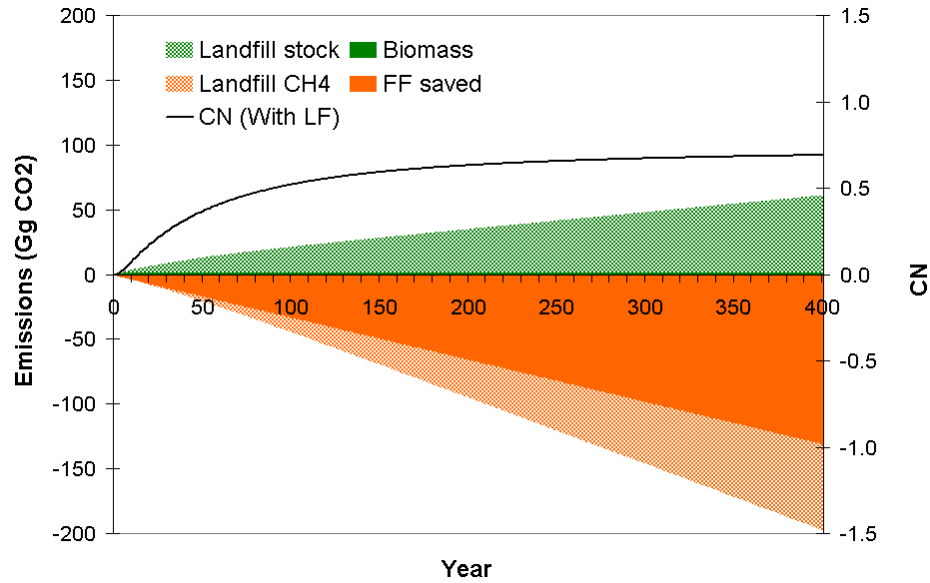


After 30 years:
CN=0.6

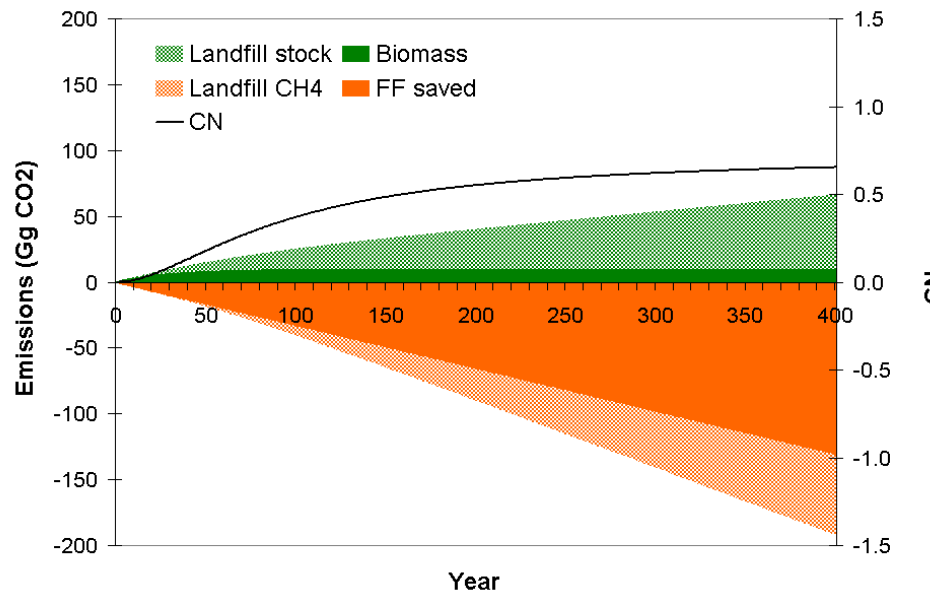
3. Change of final use (different products)

- Rotation period: 90 years (→ 90 ha)
- Baseline:
 - 1) Production of paper or
 - 2) Harvested wood products (HWP)
- New Management: production of bioenergy with the same wood
- Includes landfill stock and landfill methane emissions

3. Change of final use (different products)



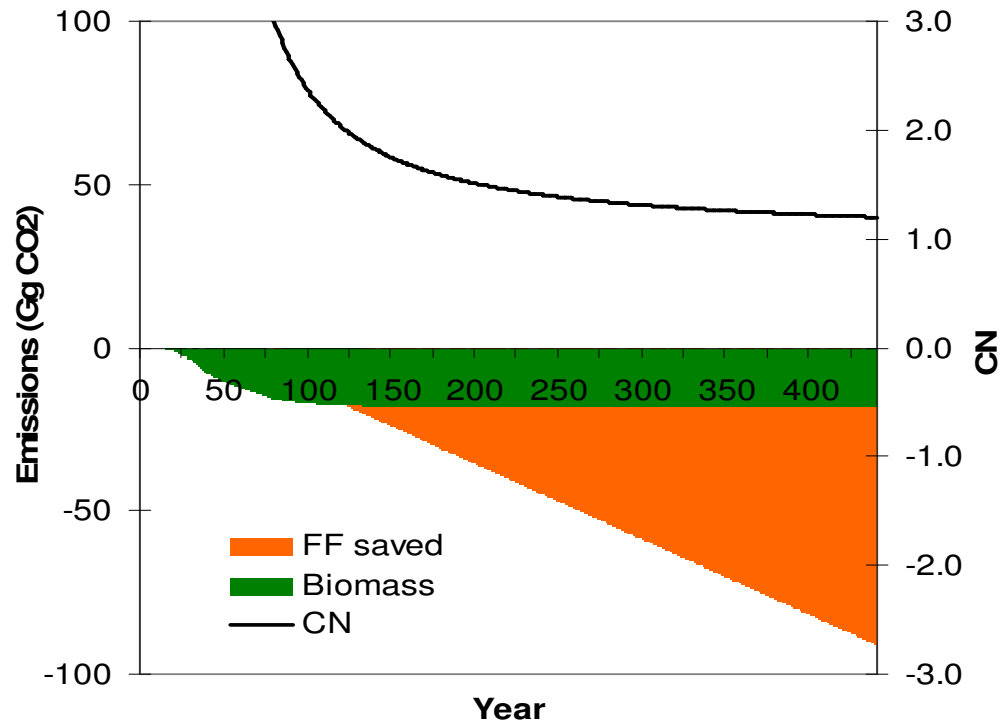
Paper vs. Bioenergy



HWP vs. Bioenergy

4. New plantations

- Baseline: cropland
- New Management: new forest to produce bioenergy (no iLUC)
- Rotation period: 40 years (→ 40 ha)



Carbon sink in the biomass + fossil fuel substitution

Other publications

- Manomet study: Walker, T. (Ed.). Contributors: Gardellichio, P., Colnes, A., Gunn, J., Kittler, B., Perschel, R., Recchia, C., Saah, D., and Walker, T. 2010. Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources. Manomet Center for Conservation Sciences. Report No.: NCI-2010-03.
- Repo A., Tuomi M., Liski J., 2010. Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues. Bioenergy: in press
- McKechnie J., Colombo S., Cheng J., Mabee W., MacLean H.L. Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. Submitted July 2010
- Palosuo T, Wihersaaari M, Liski J, 2001. Net Greenhouse Gas Emissions due to energy use of forest residues –Impacts of soil carbon balance. Woody biomass as an energy source – Challenges in Europe. EFI proceedings no 39, 2001
- Schlamadinger B and Spitzer J, 1994. CO₂ mitigation through bioenergy from forestry substituting fossil energy. In: Biomass for energy, environment, agriculture and industry. Proceedings of the 8th European Biomass Conference. Vienna, Austria, 3-5 October 1994, Volume 1. Ed. Chartier P., Beenackers A.A.C.M., Grassi G., pp. 310-321.
- Schlamadinger B, Spitzer J, Kohlmaier GH, Lüdeke M, 1995. Carbon balance of bioenergy from logging residues. Bioamss and Bioenery 8 (4): 221-234.
- Schlamadinger B and Marland G, 1996. The role of forest and bioenergy strategies in the global carbon cycle. Biomass and Bioenergy 10 (5/6): 275-300.

Conclusions

1. A comparative approach show the advantages and disadvantages of a system substituting another one (hidden under the current accounting system)
2. Different biomass sources have very different GHG profiles

- Support the right alternatives to fossil fuels according to the policy goal we want to achieve
- Research results can be integrated in current accounting systems (how?)

Thank you!

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