Green or Grey?

How can delimitation system boundary lead to misleading results? A case study from biomass power production

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- Introduction and objectives
- Method
  : Life cycle impact assessment including impacts from indirect land use changes
- Results and discussions
- Uncertainties
- Conclusions and perspectives

Introduction

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- Climate Change
  : Global warming and targets for CO_2 emission reductions
- Renewable energy
  : Biomass power production
- Biomass ≠ Carbon neutral
- Biomass => Impacts on human health, biodiversity, resource and society?

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Objective

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Identify how the impacts on ecosystems, human health and resource can be misinterpreted by application of various system boundaries with focus only on carbon calculations

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Methods

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- Life cycle assessment
- Cause-effect modeling approach (clca)
  : Marginal (actual affected) suppliers/technologies
  : Avoid system allocation by system expansion
- Life cycle impact assessment methods
  : STEPWISE 2006 (*Weidema et al., 2008*) – Main method
  : ReCiPe 2008 (*Goedkoop et al., 2009*)
  : EDIP 2003 (*Hauschild and Potting, 2005*)

Methods

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- Indirect land use changes (*Schmidt et al., 2010*)
  : Natural forests => Plantation forests
  Land transformation - changes in carbon stocks

  : Agricultural lands => Plantation forests
  i. Land transformation – Deforestation
  ii. Intensification – Yield improvement by applying N fertilizer
  iii. Crop displacement

Scenarios

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9 Scenarios

DK 0-alternative

: The situation without using biomass resources

: Existing coal-fired CHP plant

: Studstrupværket plant Unit 3 (SSV3) is chosen as representative

DK forest scenarios

: Modified the existing coal-fired CHP plant

: Use wood pellets/chips as fuel

DK agriculture scenario

: Modified existing coal-fired CHP plant

: Use wheat straw (20%) and coal (80%) as fuels

Scenarios

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Scenario	Conversion technology	Type of plant	Type of fuel (source)	
DK 0-alternative	Combined heat and power plant (CHP)	Existing	Coal	DKSc0
DK Forest	CHP	Existing	Wood pellets (Brazil; plantation forests; standalone production - marginal)	DKSc1
		Existing	Wood pellets (Chile; plantation forests; standalone production - marginal)	DKSc2
		Existing	Wood pellets (Baltic States; plantation forests; standalone production)	DKSc3
		Existing	Wood chips (Local production; plantation forests; standalone production; land use impacts on agricultural land)	DKSc4
		Existing	Wood pellets (Canada; natural forests; co-production with wood products)	DKScA
		Existing	Wood pellets (Russian Federation; primary forests; co-production with wood products)	DKScB
		Existing	Wood pellets (Brazil; plantation forests; standalone production; land use impacts on agricultural land)	DKScC
DK Agriculture	CHP	Existing	Wheat straw (local production; co-combustion with coal)	DKSc5

Functional units

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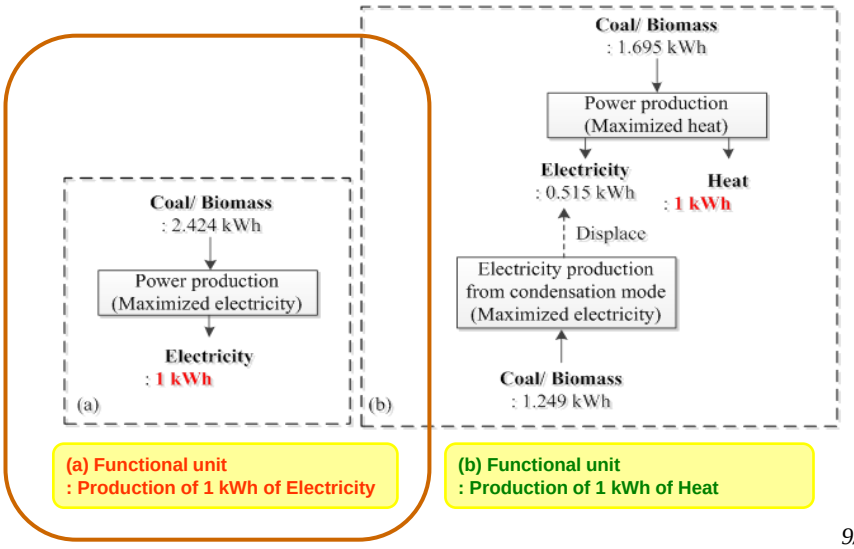

(a) Functional unit
: Production of 1 kWh of Electricity

(b) Functional unit
: Production of 1 kWh of Heat

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Global warming

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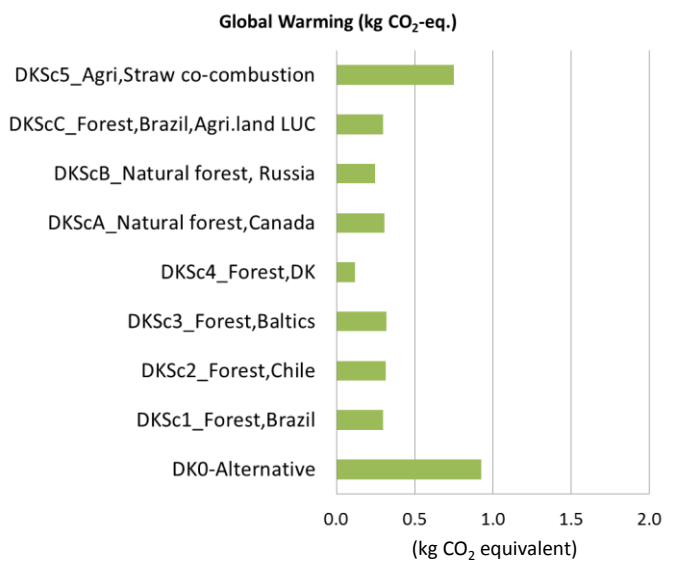

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Global warming

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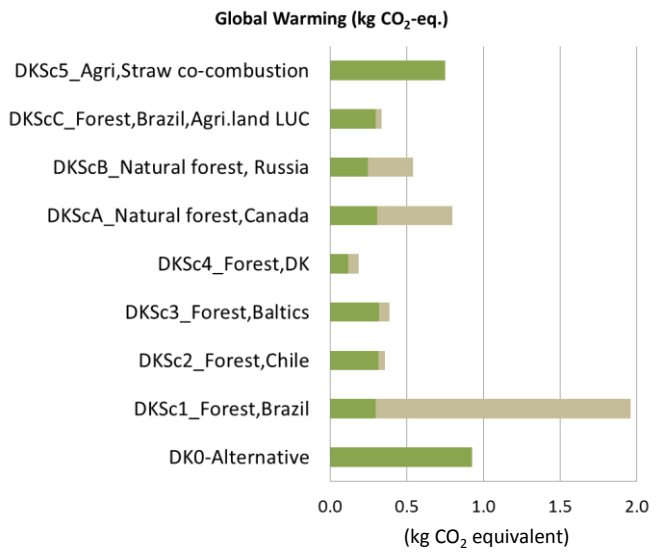

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Global warming

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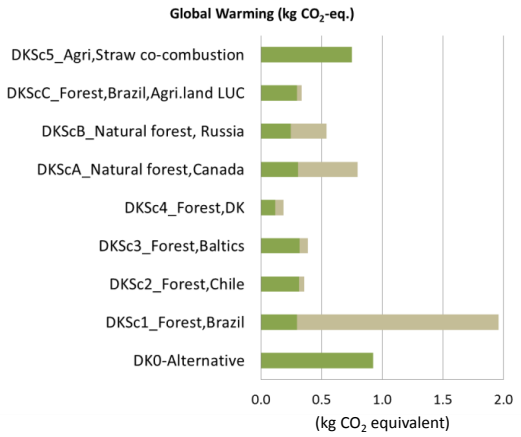

Hot spots	•Plantation (ILUC) •Wood pellet production •Combustion of fossil fuels
Contributors	•CO_2
ILUC (Grey shade)	•Wood pellet from Brazil (DK_Sc1) yields twice CO_2 eq. emissions of 0-alternative •Most of ILUC from European countries, which will transform agricultural land to plantation forest, may affect crop displacement

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Nature occupation

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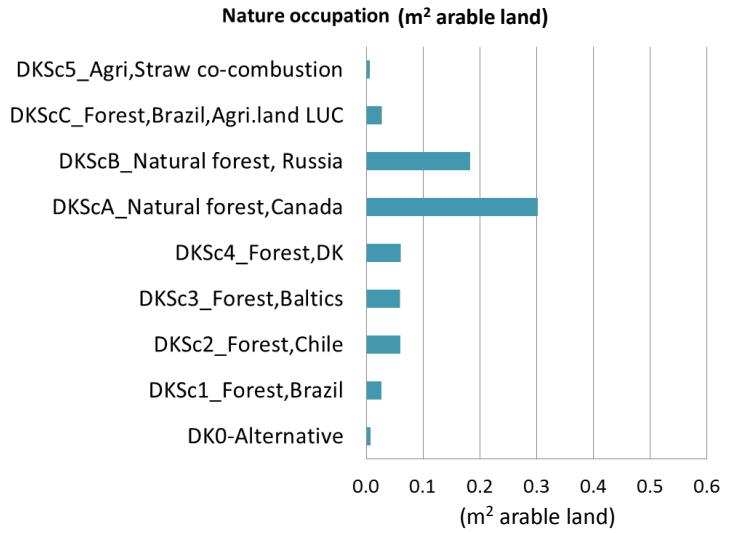

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Nature occupation

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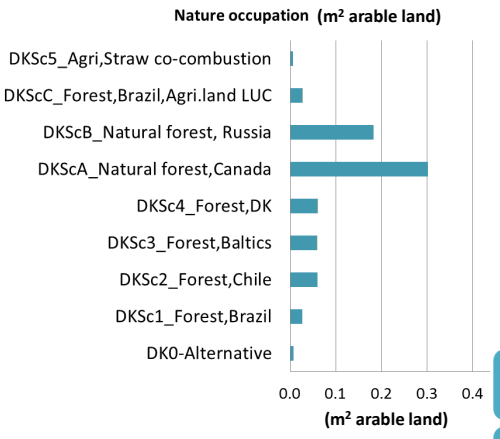

Hot spots	• Plantation
Contributors	• Occupation of land
ILUC (Grey shade)	• Non-significant contribution

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Respiratory inorganics

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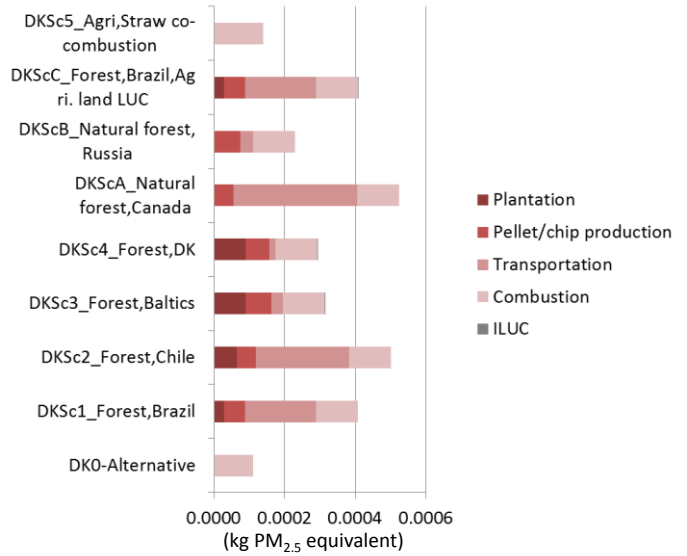

Respiratory inorganics

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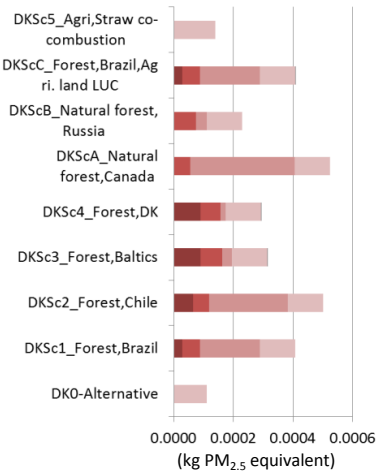
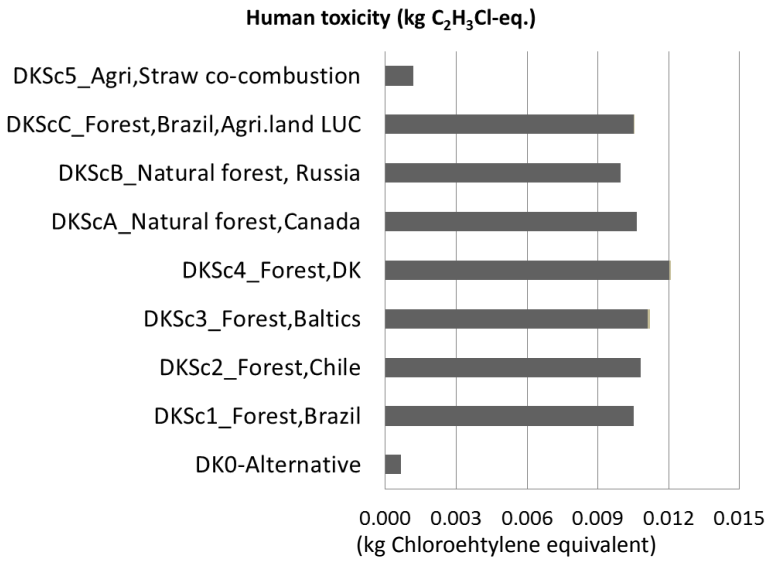


Plantation
Pellet/chip production
Transportation
Combustion
ILUC

Hot spots	•Transportation •Combustion process
Contributors	•NOx, SO_2, $PM_{2.5}$ (Particulate matters with diameter < 2.5 µm)
ILUC (Grey shade)	•Non-significant contribution

Human toxicity, non-carcinogens



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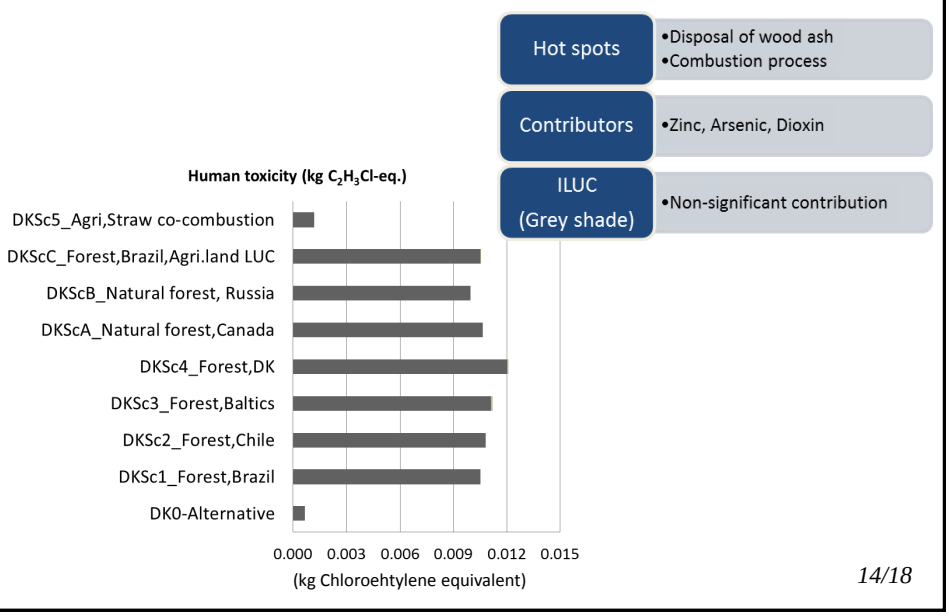
Human toxicity, non-carcinogens



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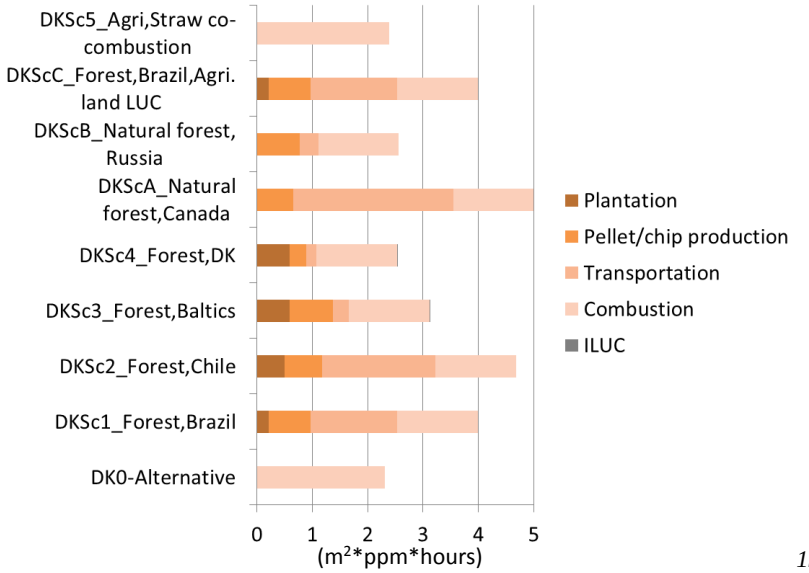
Photochemical ozone on vegetation



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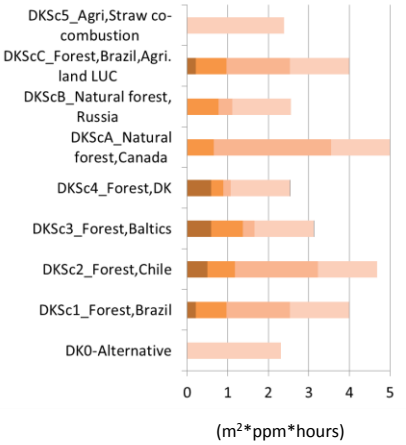
Photochemical ozone on vegetation



Hot spots	•Transportation •Combustion process
Contributors	•NOx
ILUC (Grey shade)	• Non-significant contribution

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Only Carbon calculation?

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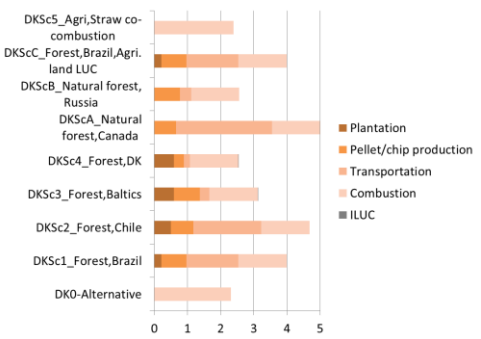

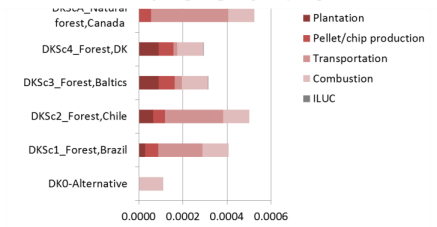

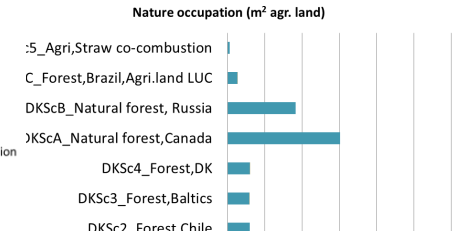

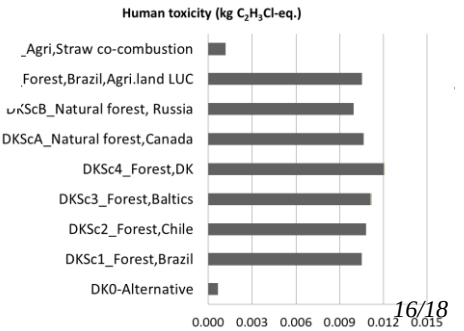

Uncertainties

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Methodology

- Identification of marginal (actual affected) suppliers
- ILUC methodology: Newly developed and still under improvement, underestimation of LUC in regions with forestry with long rotation time => the potential for carbon storage in intact forest over time is not included

Database

- Major part of data is not site-spefic

Sensitivity checks

- Other factors (e.g. forest yields and species, land use types in land transformation) are needed to be checked

Conclusions and perspectives

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The focus only direct "carbon" calculation in biomass power production may mislead the conclusions because non-counted CO_2 emissions from indirect land use changes may larger than CO_2 emissions from coal combustion

The focus only "carbon" in biomass power production excluding lead to adverse impacts on human health (respiratory effects, human toxicity), biodiversity (from nature occupation and photochemical ozone on vegetation), and society (from hidden socio-economic impacts).

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