

Greenhouse gas (GHG) balances of liquid biofuels

Bioenergy NoE Final Seminar
November 2nd & 3rd, 2009
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VTT TECHNICAL RESEARCH CENTRE OF FINLAND

Outline

- Background
- Biofuel pathway
- Main approaches in LCA
- GHG balances of various biofuels
- Critical issues affecting GHG balances
- Sustainability criteria for biofuels
- Case example of GHG balances according to the EU RED
- Towards sustainable biofuels
- Conclusions

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Background

- The use of biofuels in transport are promoted in many countries
- Key drivers for boosting biofuels:
 - **Mitigation of climate change**, reduction of oil dependency, improvement of energy self-sufficiency and security of supply, improvement of local economy and employment
- Global GHG emissions need to peak by 2015 and be further reduced by at least 50-85 % by 2050 from the level of 2000
- Biomass and land-area are limited resources
- Assessments of bioenergy potentials up to 2050 vary significantly
 - Very optimistic up to 1100 EJ/a
 - Optimistic 200-400 EJ/a
 - Sustainable potential only 40-85 EJ/a? → 10-20% of the current fossil energy use

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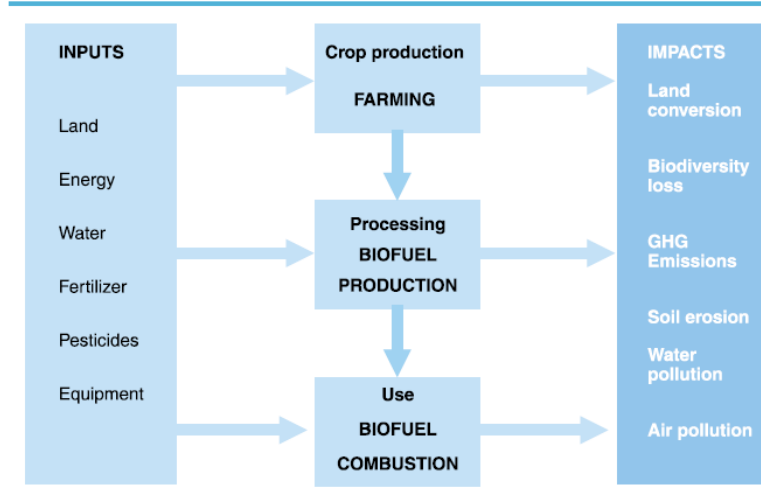
Background

- A huge number of studies with a wide range of results for GHG balances of biofuels carried out internationally
- Concern about environmental and social problems related to biofuel production increased
- Initiatives and proposals for sustainability criteria and standard methodology to assess GHG balances (including the EU RED)
- Criticism against sustainability criteria raised due to various reasons

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Biofuel pathway



Source: UNEP 2009

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Main approaches in LCA

- *Attributional (Retrospective) LCA* → "to describe the environmentally relevant physical flows of a past, current, or potential future product system at a given point of time"
 - statistics, average values
 - allocation?

as is

 - Suitable for describing the system
 - Cannot describe the impacts of any change

- *Consequential (Prospective) LCA* → method aiming to describe how environmentally relevant flows would have been or would be changed in response to possible decisions that would have been or would be made (Ekvall et al. 2005)
 - extension of the system boundary, marginal values
 - perception, data availability?

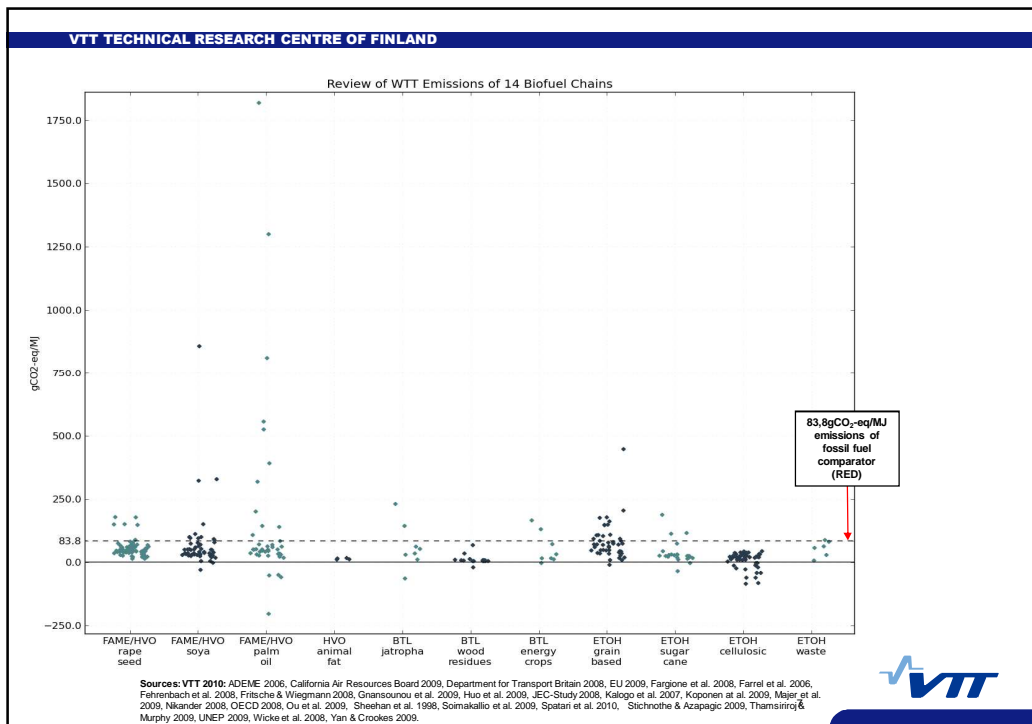
what if

 - Suitable for describing the consequences
 - Cannot be carried out in a comprehensive manner

Definitions by e.g. Ekvall & Weidema 2004, Ekvall et al. 2005, Thomassen et al. 2008, Finnweden et al. 2009

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Critical issues affecting GHG balances

- Spatial system boundary setting – *Attributional or consequential?*
- Dynamic system boundary setting – *Carbon pay back time allowed?*
- Reference scenario setting – *What is compared with what?*
- Indicators – functional units?
- Other methodological choices – *Allocation procedure, parameters?*
- Product chain specific properties – *raw material, process, utilisation?*

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Sustainability criteria for biofuels

	EU	NED	UK	GER	RSB	Swan label	RSPO	BSI	RTRS	FSC	PEFC
Applicability	BF	BF/ BM/ BE	BF	BM	BF	BF	BM	BM	BM	BM	BM
Environmental aspects											
<i>Climate change</i>	+	+	+	+	+	+	+	-(+)	-	-	-
<i>Energy balance</i>	-	-	-	(+)	(+)	+	-	-	-	-	-
<i>Air quality</i>	-	+	+	+	+	-	+	+	-	-	-
<i>Water quality</i>	(+)	+	+	+	+	-	+	+	+	+	+
<i>Use of water</i>	-	+	+	+	+	-	+	+	+	(+)	(+)
<i>Soil quality</i>	(+)	+	+	+	+	-	+	+	+	+	+
<i>Ecotoxicity</i>	(+)	+	+	+	(+)	-	+	+	+	+	+
<i>Human toxicity</i>	-	-	-	-	-	+	-	+	-	-	-
<i>Biodiversity</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Sustainable land use and competition with other resources</i>	+	+	-	+	+	-	+	-	(+)	+	+
<i>GMOs</i>	-	-	-	-	+	-	+	-	-	+	-(+)*
<i>Waste management and recycling</i>	-	+	(+)	-	-	-	+	-	-	+	-
Social impacts	-	+	+	-	+	+	+	+	+	+	+
Economic impacts	-	+	-	-	+	-	+	+	+	+	+

+ indicates that the category is TO SOME EXTENT considered
 (+) indicates that the category is mentioned only in GENERAL LEVEL
 - indicates that the category is NOT considered

BM = Biomass
 BE = Bioenergy
 BF = Biofuel

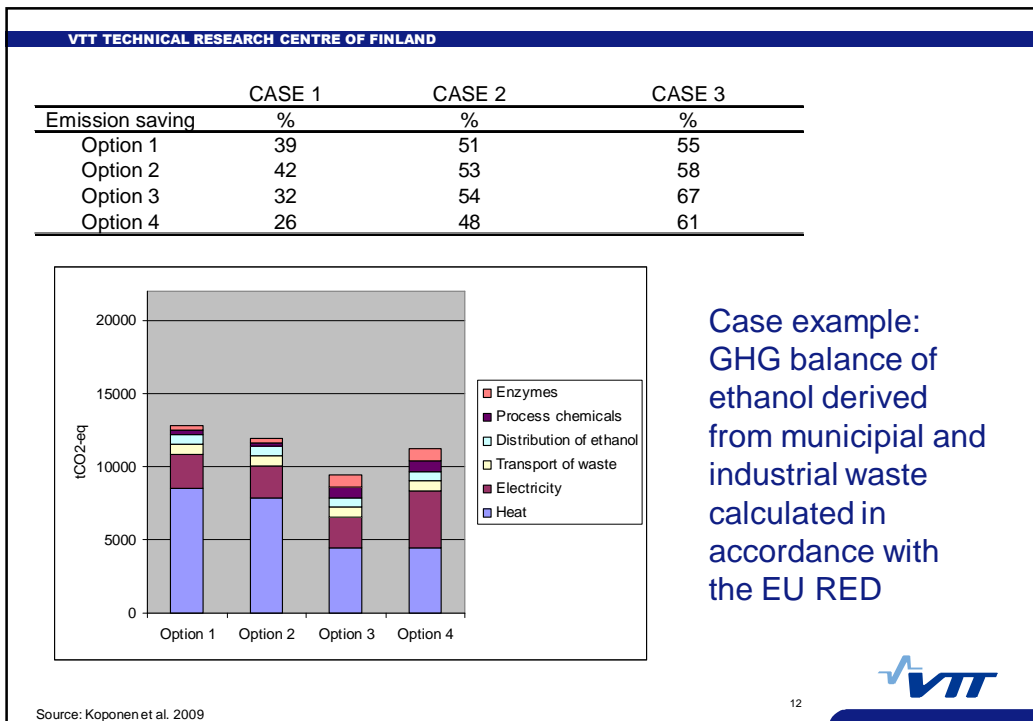
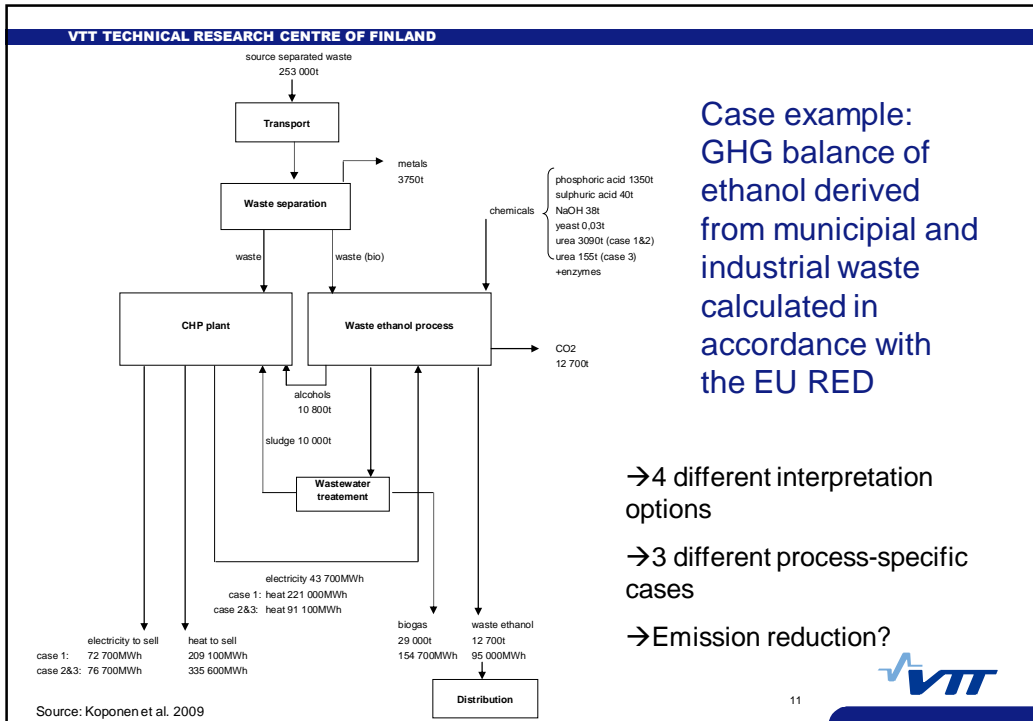


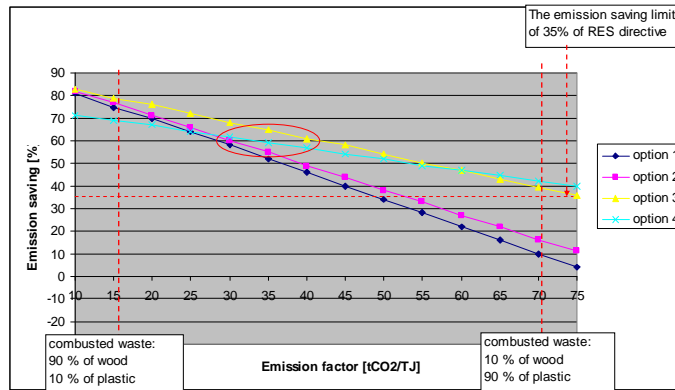
Source: Soimakallio et al. 2009

SUMMARY OF INITIATIVES, GHG SUSTAINABILITY	EU RES	NED	UK	GER	RSB	Swan label	RSPO
Spatial system boundary							
- clear definition	(Yes)	(Yes)	(No)	(No)	(No)	(No)	(No)
- competition of land use considered	No	(Yes)	No	(Yes)	(Yes)	No	(Yes)
- competition of raw material use considered	(Yes)	(Yes)	(No)	(Yes)	(Yes)	No	No
- production of machines, infrastructure, plants considered	No	(No)	(No)	No	No	No	No
- allocation procedure proposed	E	S/(P)	S/(P,E)	No	(S/E/P)	No	No
- relevant Kyoto greenhouse gases considered	Yes	(Yes)	Yes	?	Yes	Yes	No
- carbon storage inside system boundary considered	(Yes)	(Yes)	(Yes)	No	(Yes)	(Yes)	No
Dynamic system boundary							
- calculation period proposed	20	(No)	(10)	No	(No)	No	No
- timing of inputs and outputs considered (radiative forcing)	No	No	No	No	No	No	No
- carbon storage inside the system boundary considered	(Yes)	(Yes)	(Yes)	No	(Yes)	No	No
Parameters							
- default values proposed	Yes	(Yes)	Yes	No	(No)	(Yes)	No
- uncertainty range proposed	(No)	(No)	(No)	No	No	No	No
- sensitivity issues considered	No	No	No	No	No	No	No
- references clearly presented	No	Yes	Yes	Yes	No	(Yes) ¹	No
- emissions of electricity	Ave	?	?/Marg	-	?	-	-
Indicators							
- relative emission reduction, (foss. - bio)/foss., [%]	Yes 35-60 %	Yes 30 %	(Yes) ?	No	Yes ?	No	No
- emission reduction per biocarbon consumed	No	No	No	No	No	No	No
- emission reduction per land area	No	(No)	No	No	No	No	No
- radiative forcing impact	No	No	No	No	No	No	No
- energy balance criteria	No	No	No	(Yes)	(Yes)	(Yes)	No

Source: Soimakallio et al. 2009







Case example:
GHG balance of
ethanol derived
from municipal and
industrial waste
calculated in
accordance with
the EU RED

→ Emission reduction significantly depend on the system boundary setting and emission factor of waste stream

→ Emission reduction can be increased by lowering the plastic content of the combusted waste, lowering the urea requirement and by applying CCS

Source: Koponen et al. 2009

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Problems and challenges of the EU RED

- Relative emission reduction indicator → Effectiveness of biomass use?
- Narrow system boundary → Perception of the consequences?
- Default values → Handling of regional differences, natural uncertainties?
- Pulse emissions from land-use changes annualised over 20 years → underestimation of the climate change effects

→ The GHG calculation methodology of the RED very much follows the attributional approach of the LCA and cannot therefore perceive the consequences of the change caused by increasing the production of biofuels

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Fundamental principle requirements for GHG benefits through biofuels

- Raw materials and land area for cultivation are available
- Life-cycle GHG impacts of the biofuel product system are (significantly) lower compared to reference (fossil) fuels
- Reference (fossil) fuels are really replaced by biofuels

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Mechanisms towards sustainable biofuels

- Effective and ambitious climate convention, sustainability standards for all biomass and land utilisation
- Comprehensive and sustainable action plan for the overall biomass and land utilisation (food, feed, fibre, energy)
- Macro-level scenario analysis of the consequences of biomass and land utilisation
- Assessing, verification and monitoring system for the actual emissions of the biofuel product systems
- Enhanced understanding of the critical issues and incentives to improve the quality of the data

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Conclusions

- Biomass and land for growing biomass are limited resources → from climate change mitigation point of view: *use them as effectively as possible in climate change mitigation*
- Production of liquid biofuels relatively energy intensive → substitution credits not (at least yet) optimal
- Cascading (when possible) likely provides more optimal credits
- For long-rotation biomass and soil carbon pools also conservation and sequestration managements need to be considered

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Conclusions

- GHG balances of biofuels depend significantly on the assumptions
- *Attributional LCA* or '*carbon footprinting*' required to recognise environmentally relevant physical flows of the product systems and to verify actual emissions
 - Standard methodology, guidelines, LCA tools, uncertainty and sensitivity analysis
- *Consequential LCA* required to assess the impacts of increasing or planning to increase the production of biofuels
 - Scenario analysis, equilibrium models, partial equilibrium models, LCA tools

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Thank you for your attention!