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Decision support in a bio-economy for comparative SIA, LCA and ESI calculations in ToSIA

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SSAFR

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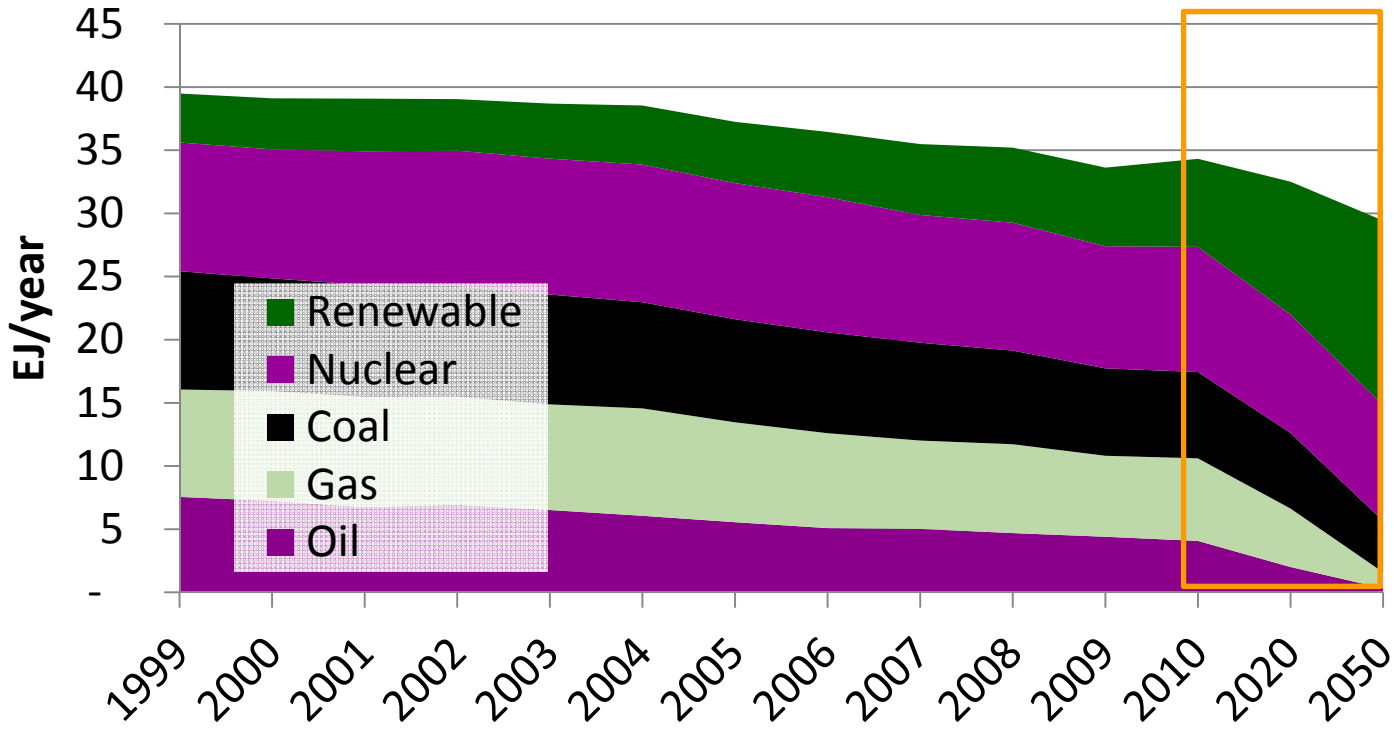
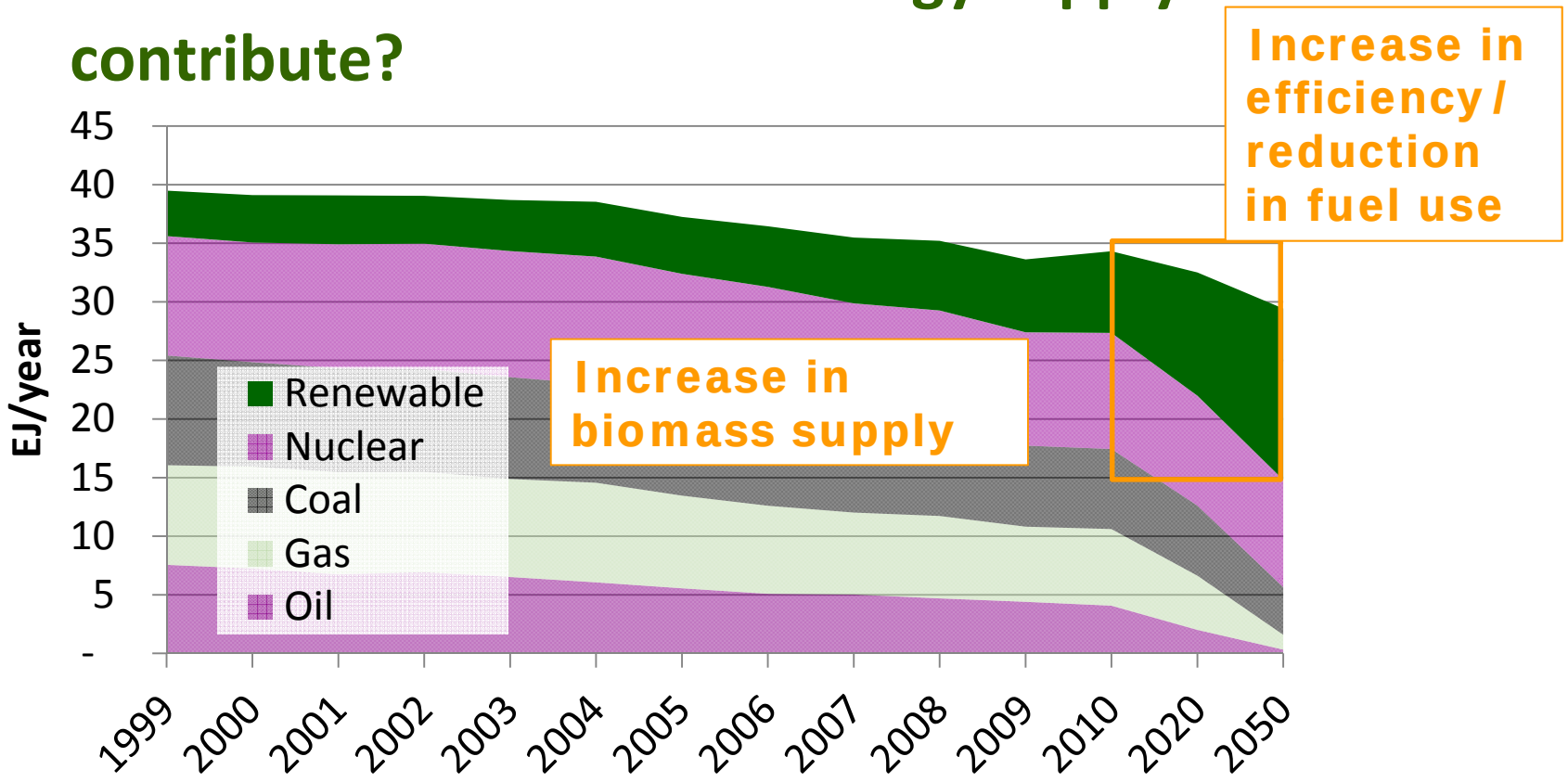
The Bio-economy Challenge



Total Production of Primary Energy, by Source, EU27, 1999-200, 2020, 2050

Source: The values from 1999 to 2010 are from Eurostat. The values for 2020 and 2050 are from the Energy Roadmap 2050, Impact Assessment and Scenario Analysis, Current Policy Initiative Scenario. (from INFRES D3.1)

The Challenge
– and how can forest bioenergy supply chains contribute?



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Background

- **Forest residual biomass is the largest source of renewable feedstock for energy in Europe.**
  - Several studies indicate that EU's forests could supply c.a. 200 million m^3 (400 TWh) more woody biomass for energy annually in coming decades.
- **New technology and logistics are needed to mobilize this potential**
  - True competitiveness can not be based on expensive subsidy measures for biomass.
- **New solutions must be taken into practice**
  - Research is important, but it only starts to effect when practice adapts it

New innovative solutions to forest biomass supply in the EU

Background

INFRES developed new machines, transportation solutions and ICT systems for whole supply chain management

23 partners, including 9 research organizations + 14 SMEs

Duration of the project is 3 years and the total budget is c.a. € 4.2 million.

Technological innovations along the supply chain

How are sustainability impacts along the (new) supply chains?
How can impacts acc to different methods be calculated in comparable ways?

Source: Alakangas

Objective

Systematic Sustainability Impact Assessment approach by ToSIA*

Method

ToSIA is a flexible tool, based on three concepts:

1. **Alternative process chains**
2. **Material flow along the chain**
3. **Indicators per process multiplied with the material flow**

ToSIA assesses the sustainability impacts of alternative supply chains.

Source: EFI

More info to ToSIA under:
http://tosia.efi.int
tosia@efi.int

* ToSIA = Tool for Sustainability Impact Assessment

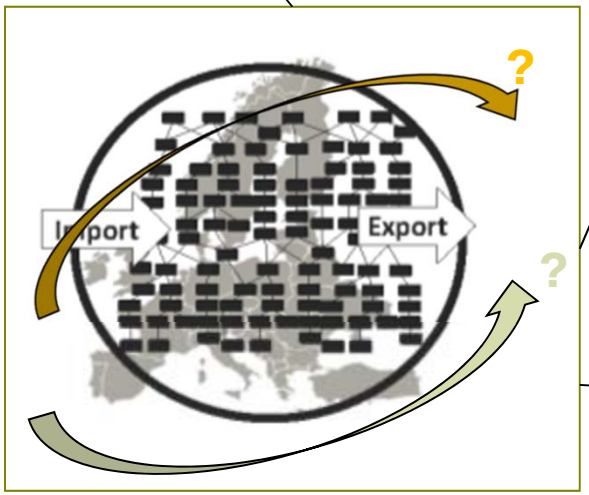
Alternative supply chains may focus on

Technological machine innovations (INFRES)

New processes or landuse structures

Increased harvesting of forest biomass for energy (adapted from EFSOSII bioenergy scenarios)

Change in material flow

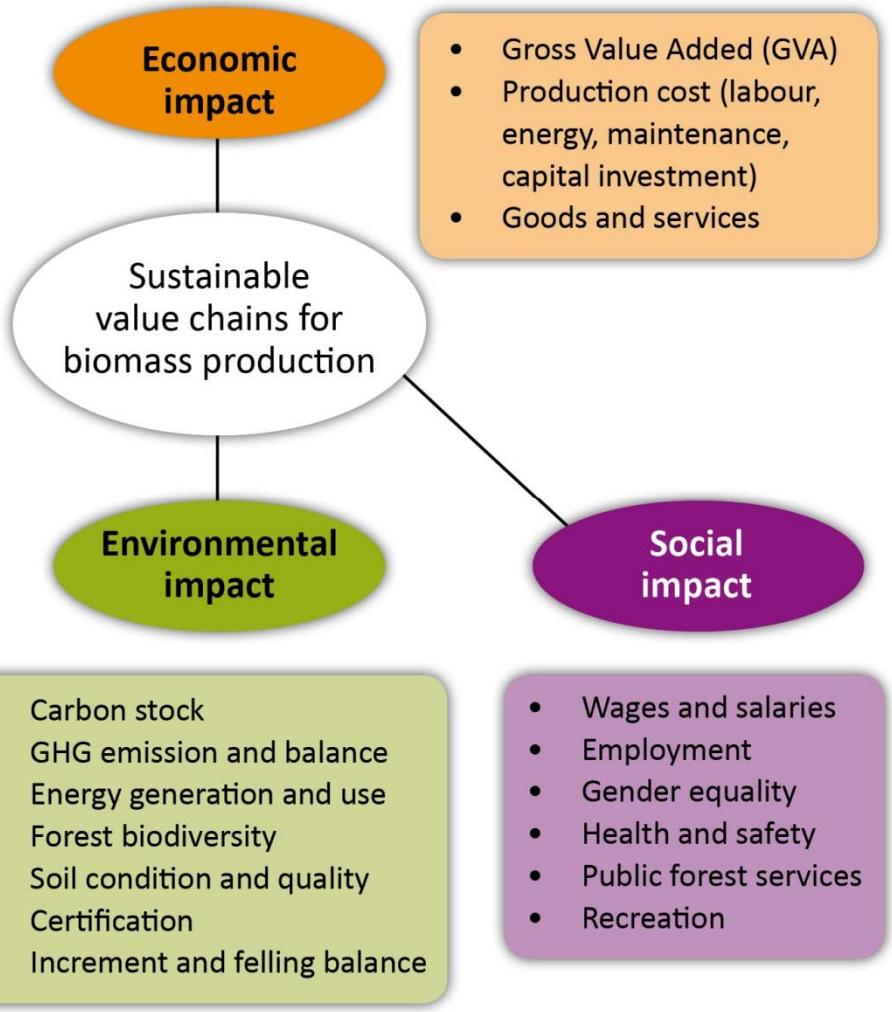


Changes in indicator values

Comparison of direct impacts, LCA and ESC indicator values

Method

New indicators: conventional ToSIA (direct impacts)



LCA
(direct and indirect Energy use + GHG emission)

ESC
(Energy conversion efficiency)

New indicators: LCA indicators (direct + indirect impacts)

Indicator ID	LCA equivalents: Name of indicator or type of element in ToSIA	Comment on use of LCA equivalent in ToSIA (in general) and in INFRES (in specific
18.2.4	Direct and Indirect Energy use (LCA)	Energy used during the operations (in form of mostly diesel) and energy required during the extraction, production and Transport of the diesel to the machine tank (in order to produce 1 MJ of diesel, 1.16 MJ of primary energy was spent)
19.2	Direct and Indirect Greenhouse gas emissions from machinery (LCA)	Emissions factors for forestry machinery and trucks are reported in (Lindholm et al., 2010)

New indicators: European Sustainability Criteria (a test case for solid biofuel)

Indicator ID	European Sustainability Criteria: Name of indicator, equivalent in ToSIA	Comment on use criteria in ToSIA (in general) and in INFRES (in specific
19.1	(19) GHG-emission	2.3 Life cycle greenhouse gas (GHG) performance
18.1, 18.2	2.4 Energy conversion efficiency (18) Energy generation and use	Energy conversion efficiency is a new ToSIA sub-indicator that builds on the existing "Energy generation and use" and takes chain structure path into account by the planned advanced aggregation methodology in ToSIA.

Method

New indicators: ESC

European methodology for GHG reduction with solid biomass combustion

Basic formula for calculating emission of solid biomass supply chains for energy generation as presented in COM(2010)11 can be reduced to

$E = e_{ec} + e_p + e_{td}$

E = total emissions from the use of the fuel before energy conversion

e_{ec} = emissions from the extraction or cultivation of raw materials

e_p = emissions from processing

e_{td} = emissions from transport and distribution

and compared to the fossil fuel comparator (FCC) with the following equation:

GHG savings (%) = (FCC-E)/FCC * 100.

Method

Direct impacts: fuel reductions

Innovation	Fuel consumption reference case (litres/m3)	Fuel consumption INFRES innovative solution (litres/m3)	Fuel consumption reduction, emission reduction (%)
Singlegrip harvester vs with MAMA head in CTL system	1.69	1.30	23%
Singlegrip harvester vs with NaarvaGrip EH28 head in CTL system	1.69	1.50	11%
Chipper vs Hybrid chipper	1.15	1.02	11%
Chipper vs Pezzolato chipper	1.15	1.06	8%

Direct + indirect impacts: fuel use

	Fuel use reference case	Direct and Indirect fuel use (LCA) (reference case)	Fuel use INFRES innovative solution	Direct and Indirect fuel use (LCA) (INFRES innovative solution)
	(litres/m3)	(litres/m3)	(litres/m3)	(litres/m3)
Singlegrip harvester vs with MAMA head in CTL system	1.69	1.96	1.3	1.508
Singlegrip harvester vs with NaarvaGrip EH28 head in CTL system	1.69	1.96	1.5	1.74
Chipper vs Hybrid chipper	1.15	1.33	1.02	1.1832
Chipper vs Pezzolato chipper	1.15	1.33	1.06	1.2296

Direct + indirect impacts: GHG emissions

	(direct) GHG reference case	Direct and Indirect GHG (LCA) (reference case)	Direct GHG INFRES innovative solution	Direct and Indirect GHG (LCA) (INFRES innovative solution)
	($kgCO_2eq/m^3$)	($kgCO_2eq/m^3$)	($kgCO_2eq/m^3$)	($kgCO_2eq/m^3$)
Singlegrip harvester vs with MAMA head in CTL system	4.47	5.18	3.44	3.99
Singlegrip harvester vs with NaarvaGrip EH28 head in CTL system	4.47	5.18	3.97	4.60
Chipper vs Hybrid chipper	3.04	3.52	2.70	3.13
Chipper vs Pezzolato chipper	3.04	3.52	2.80	3.25

Comparison of impacts: emission and emission reduction (ESC)

	Reference	Scenarios with INFRES innovations				
	Whole chain	MAMA head	NaarvaGrip EH28	Hybrid chipper	Pezzola to chipper	Average improvement
Emissions supply chain (gCO2/MJ)[a)]	2.15	2.01	2.08	2.10	2.12	2.01
Fossil fuel comp. heat (gCO2/MJ)	80.0	80.0	80.0	80.0	80.0	80.0
Emission reduction supply chain	97.31%	97.48%	97.40%	97.37%	97.35%	97.49%
Improvement compared to baseline		0.15%	0.08%	0.05%	0.04%	0.16%

Discussion:

- This system is a process-based approach, with focus on alternative decisions on on process performance. It does not replace an LCA if the focus is on the product's environmental load or for EPD.
- Same reference to core processes make values from different methods comparable
- Gives impacts of changes in a comparative manner for the change (e.g. new technologies) and for the diffeent methods.
- However, even more attention is required
- Data quality is crucial, even more for LCA aspects (but extensive upstream data tends to be unavailable)

Outlook:

- **Further testing and development of the concept to wider and different supply chains.**
- **Expansion of concept, also to economic and social dimension**

Thanks a lot for your attention!

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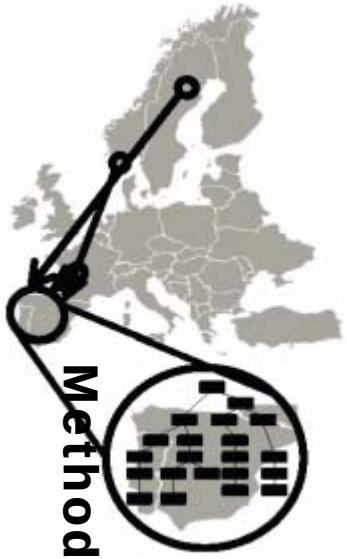
Indicators in ToSIA (so far)



Method

Indicators

Economic

- Gross value added
- Production costs
- Resource use
- Total production
- Labour productivity
- Investment, Research and Development
- Trade balance
- Enterprise structure
- Husbandry herd balance
- Loss and compensation of reindeer
- Innovation

Environmental

- Energy generation and use
- Greenhouse gas emissions and carbon stocks
- Transport distance and freight
- Forest biodiversity
- Forest resources
- Water and Air pollution
- Generation of waste
- Forest damage
- Soil condition
- Water use
- Foraging resources

Social

- Employment
- Wages and salaries
- Occupational health and safety
- Education and Training
- Consumer behaviour and attitude
- Corporate social responsibility
- Provision of public forest services
- Quality of employment
- Recreational value and Aesthetics

Indicators can be defined and selected to suit any particular study.
Other qualitative and cultural indicators are also possible to include.

Direct impacts: turnover from feedstock supply

Production cost for additional small-dimension timber	CEU	SEU	NEU	EEU	EU
extra cost [EUR/m3]	44	0	8	15	22
stump extra cost [EUR/m3]			16		16

This service value was multiplied with the volumes provided, and yielded **0.9 Mio EUR in 2010 up to 3.4 Mio EUR in 2030**.

Direct impacts: increase in employment

Extra employment per region and assortment chain	Pre-commercial extra FTE [FTE/m3]	Harvest residue extra FTE [FTE/m3]	Stump extra cost FTE [FTE/m3]
CEU	0.00039	0.00033	
SEU	0.00017	0.00008	
NEU	0.00018	0.00009	0.00018
EEU	0.00024	0.00018	
EU	**0.00098**	**0.00069**	**0.00018**

	2010 (BAU)	2015	2020	2030
Increased manpower from additional volumes and improved harvesting technology	+74938 FTE	+211461 FTE	+297980 FTE	+311132 FTE