How to ensure bioenergy production in a sustainable and efficient manner in Norway?
– From strategies to actions

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"Sustainability and efficiency in bioenergy production"

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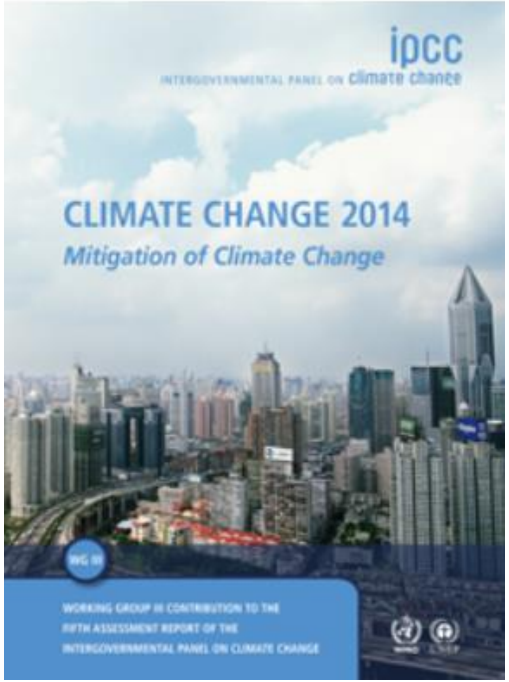
Main achievements the past 5 years

- NTNU/IndEcol has participated in the last Intergovernmental Panel on Climate Change (IPCC) report
- IPCC is the <u>leading international body for the assessment of climate change</u> (http://www.ipcc.ch/).
- Established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (VMO) in 1988 to provide the world with a <u>clear scientific view</u> on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.
- <u>Thousands of scientists from all over the world</u> contribute to the work of the IPCC on a voluntary basis.
- Review is an essential part of the IPCC process, to ensure an objective and complete assessment of current information.
- IPCC aims to reflect a range of views and expertise.
- Because of its scientific and intergovernmental nature, the IPCC embodies a unique opportunity to provide rigorous and balanced scientific information to decision makers.
- NTNU/ IndEcol has participated in
  - Chapter 7: Energy Systems
  - Chapter 11: Agriculture, Forestry and Other Land Use (AFOLU)
- Link to report http://mitigation2014.org/report/publication



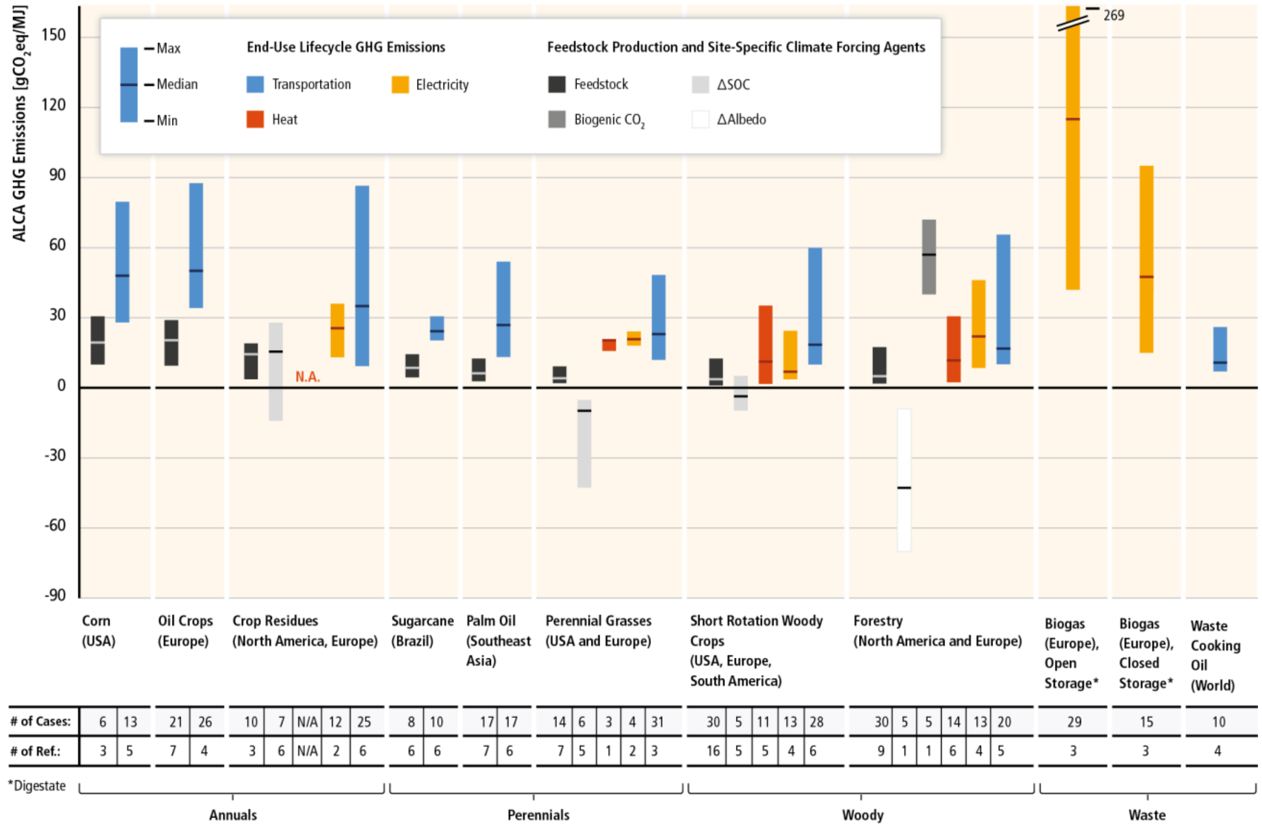
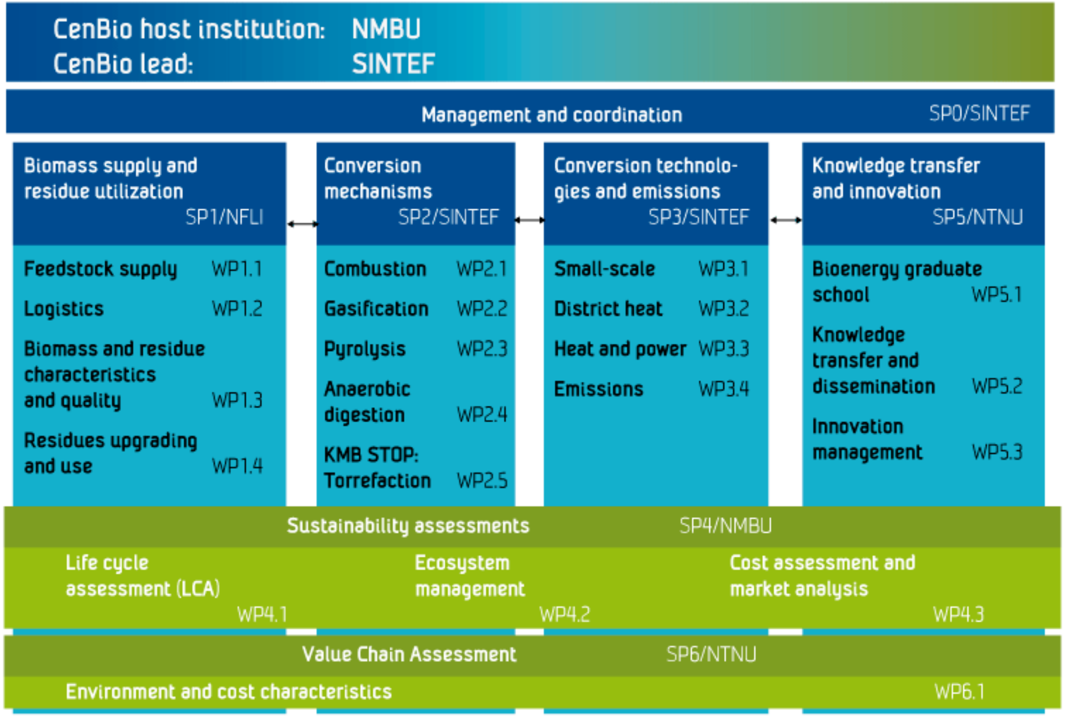


Figure 11.23 from illustrates the range of lifecycle global direct climate impact (in g CO2 equivalents per MJ, after characterization with GWP time horizon=100 years) attributed to major global bioenergy products reported in the peer-reviewed literature after 2010.
http://mitigation2014.org/report/figures/chapter-11-figures/figure-11-23-pdf.pdf

Sustainability aspects are essential for policy design and development



CenBio aims at enabling sustainable and cost-efficient bioenergy.

CenBio address the entire value chains of virgin biomass and biodegradable waste fractions, including their production, harvesting and transportation, their conversion to heat, power and biogas, and the handling and upgrade of residues to valuable products.

This is a formidable task, requiring knowledge and competence from numerous research disciplines and industrial sectors.

SP6-Value Chain Assessment-
Leader: Anders H. Strømman

- The goal of SP6 requires a thorough and detailed assessment of the existing bio-energy chains as well as of the possible future options. This research is essential to provide sustainable directions for the national goal of doubling bioenergy production by the year 2020.

- The specific objective of SP6 is to identify the portfolio of individual value chains that will enable a sustainable increase of bioenergy utilization in Norway. This task entails the following four sub-objectives:

- Identification of the environmental and economic characteristics of the Norwegian bioenergy system:
  1. Current system: Individual performance >> value chains
  2. Current system: Total performance >> whole system
  3. Novel system: Individual performance >> value chains
  4. Novel system: Total performance >> whole system

Methodology - Life Cycle Assessment

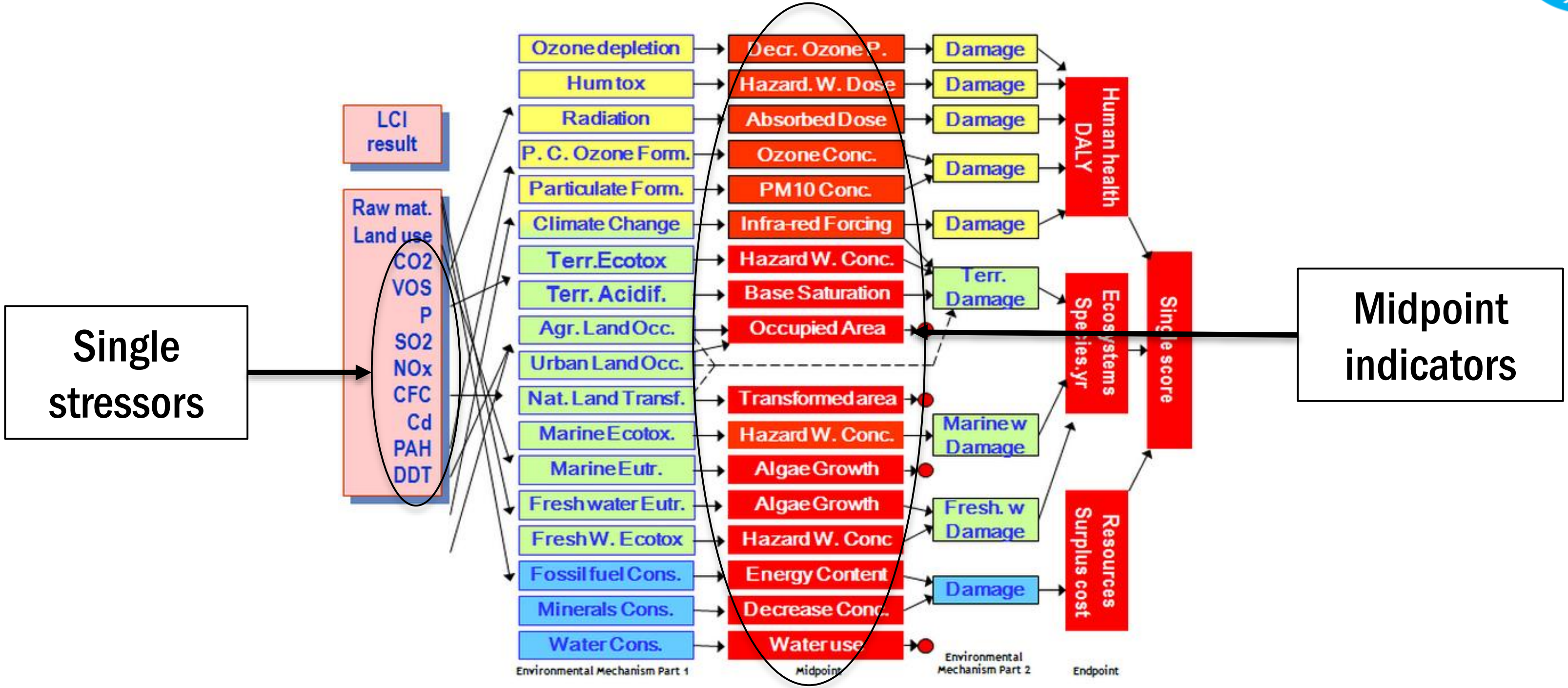
- Life Cycle Assessment (LCA) was developed as a method to determine the embodied energy use and environmental pressures associated with specific product systems (Finnveden et al., 2009)

- A product system describes the production, distribution, operation, maintenance, and disposal of the product.

- Key issues for bioenergy LCAs are (Cherubini and Strømman, 2011):
  - System definition including system boundaries
  - Functional units
  - Reference system
  - Selection of methods for considering energy and material flows across system boundaries

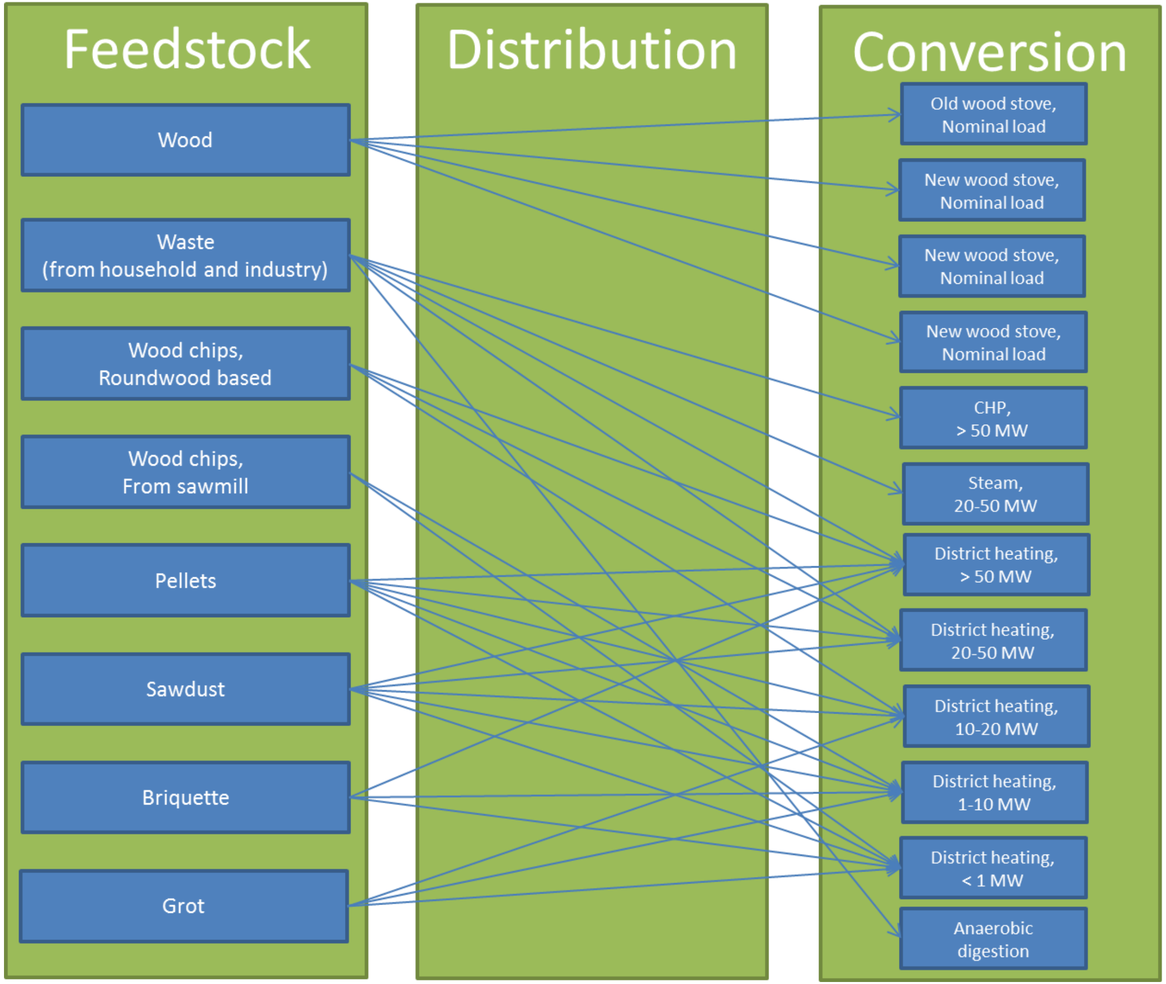
- Functional unit
  - Reference to which the input and output process data are normalized and the basis on which the final results are shown. (Cherubini and al., 2009):

LCA-Impact assessment method

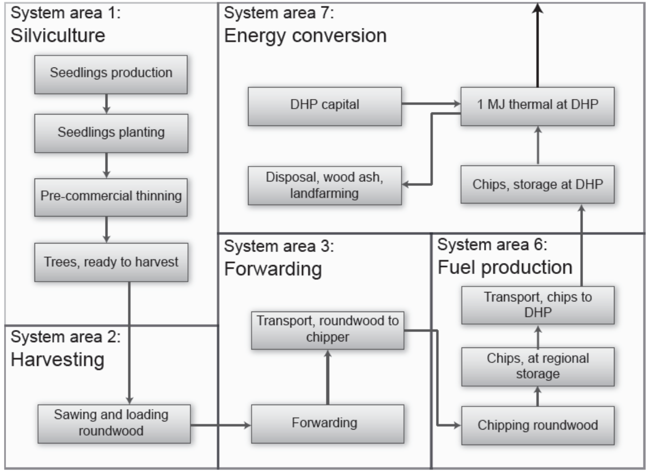


Relationship between life-cycle-inventor (LCI) parameters (left), midpoint indicator (middle) and endpoint indicator (right). http://www.lcia-recipe.net/project-definition

Cenbios
30 value chains



Value chains versus system areas



Value chain:
Wood chips to district heating plant (DHP)

FULL NAME	Name	UNIT		Seedlings production	Seedlings planting	Pre-commercial thinning	Trees, ready to harvest	Sawing and loading GROT	Forwarding	Transport, GROT to chipper	Transport, chips to DHP	Chipping GROT	Chips at regional storage	Disposal, wood ash	DHP capital	Chips, storage at DHP	1 MJ thermal at DHP - f.u.
Seedlings production	SA1 = Silviculture	unit			x												
Seedlings planting		ha					x										
Pre-commercial thinning		ha					x										
Trees, ready to harvest		m3											x				
Sawing and loading GROT	SA2 = Harvesting	hr											x				
Forwarding	SA3 = Forwarding	m3											x				
Transport, GROT to chipper	SA5 = Transportation	tkm											x				
Transport, chips to DHP		tkm														x	
Chipping GROT	SA6 = Fuel Preparation	kg											x				
Chips at regional storage		m3														x	
Disposal, wood ash	SA7 = Energy Conversio	kg															x
DHP capital		unit															x
Chips, storage at DHP		m3															x
1 MJ thermal at DHP - f.u.		MJ	1														

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Importance of the functional unit

Value chain: Waste (municipal and commercial) to district heating-Waste-to-Energy (WtE) plant

WtE plants fulfill two functions:

(1) **Waste treatment** - Acts as a sink for pollutants with its thermal treatment processes destroying organic pollutants and extracting chemical pollutants via advanced flue gas cleaning systems

(2) **Energy producer** - Reduces the dependency towards electricity and fossil sources for heating.

Two functions>> two functional units (f.u.)

f.u. 1 >> "input-based", defined by the waste amount entering a given facility

f.u. 2>> "output-based", defined by amounts of produced energy.

Different f.u. lead to different results>>Insertion of new «dirty» waste fractions with high calorific values might:

- Increase the total environmental impact of the system considered in a waste management perspective (f.u.1),
- But reduce the environmental burdens in an energy production perspective (f.u.2)

Thank you for your attention’

References

Cherubini, F., N. D. Bird, A. Cowie, G. Jungmeier, B. Schlamadinger, and S. Woess-Gallasch. 2009. Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations. Resources, Conservation and Recycling **53**:434-447.

Cherubini, F., and A. H. Strømman. 2011. Life cycle assessment of bioenergy systems: State of the art and future challenges. Bioresource Technology **102**:437-451.

Finnveden, G., M. Z. Hauschild, T. Ekvall, J. Guinée, R. Heijungs, S. Hellweg, A. Koehler, D. Pennington, and S. Suh. 2009. Recent developments in Life Cycle Assessment. Journal of Environmental Management **91**:1-21.