Multidimensional sustainability framework to evaluate forest-based bioenergy systems

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Project background

BioSus – A multidimensional sustainability framework to evaluate forest and wood energy production, 1.7.2009 – 31.12.2011, funded by Tekes (the Finnish Funding Agency for Technology and Innovation)

Research partners:

Finnish Environment Institute

University of Eastern Finland

Finnish Forest Research Institute

Project background

- In Finland, forest biomass is the most effective ways to produce renewable energy in a large scale
- The development has been fast, the production of forest chips to be used in energy production has increased rapidly during the last ten years
- The “new form” of utilization requires also effective tools for policy making and nature resource management

Project aims

- The first aim is to develop a framework (tool) to analyze multidimensional sustainability; ecological, economic, social and cultural criteria

- The second aim is to test the framework with four bioenergy production chains located in Eastern Finland

1. Local heat entrepreneurship by using forest chips
2. Wood and peat combustion in large CHP plant
3. Wood pellets production
4. Biodiesel production

Questions to be answered

- How sustainability should be defined in bioenergy production context?
- How the sustainability could be developed further?
- What are limits of the data availability and methodological challenges?

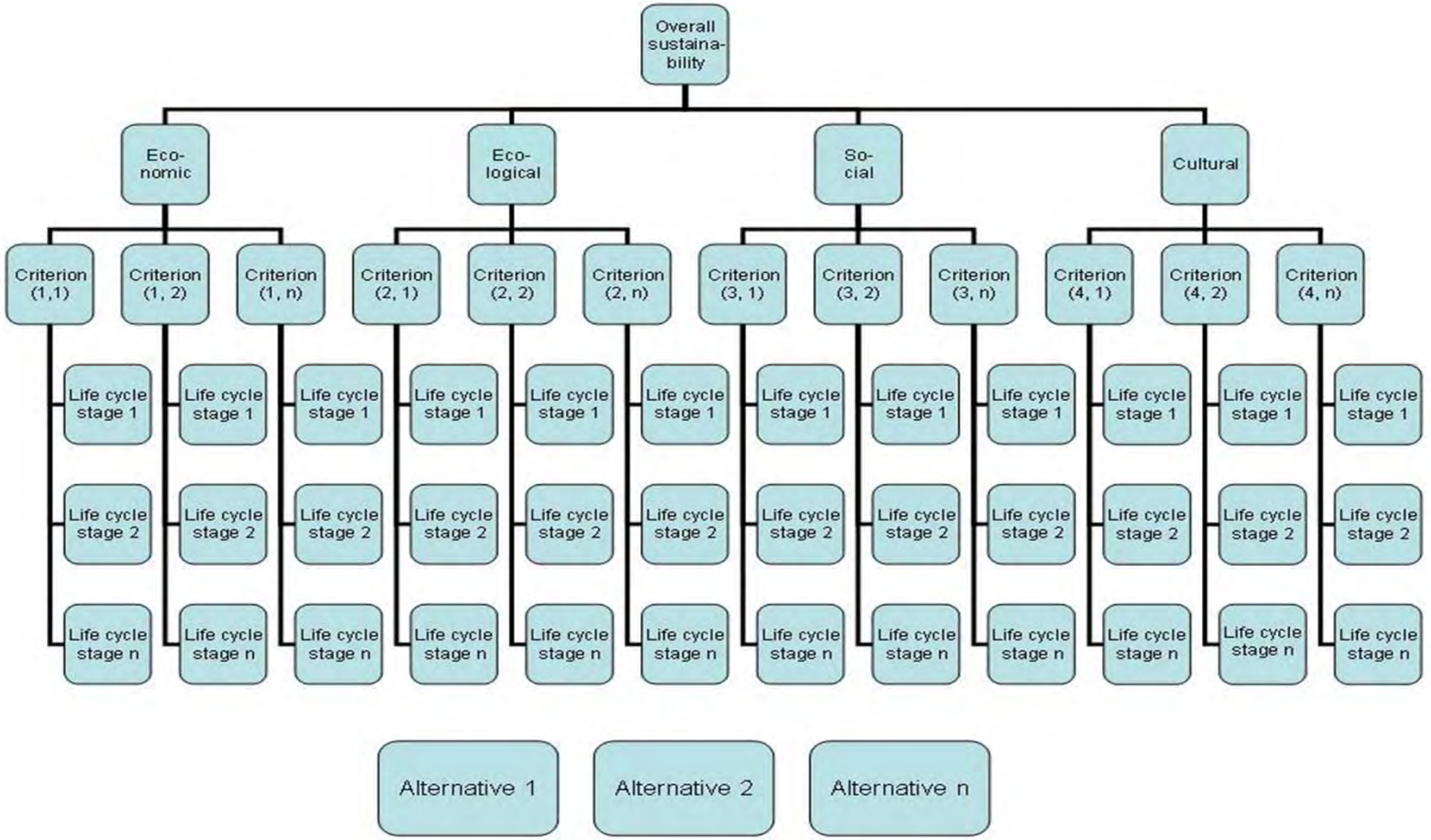
- What is “the best” production chain with selected criteria and indicator weights?
- What is the optimal allocation of resources between different production chains?

Methods

Methods to be used include life-cycle analysis (LCA) and multi-criteria decision analysis (MCDA)

- LCA is extended by including economic, social and cultural indicators
- MCDA is employed in indicator definition phase and analysis of trade-offs between different indicators

Theoretical assessment framework

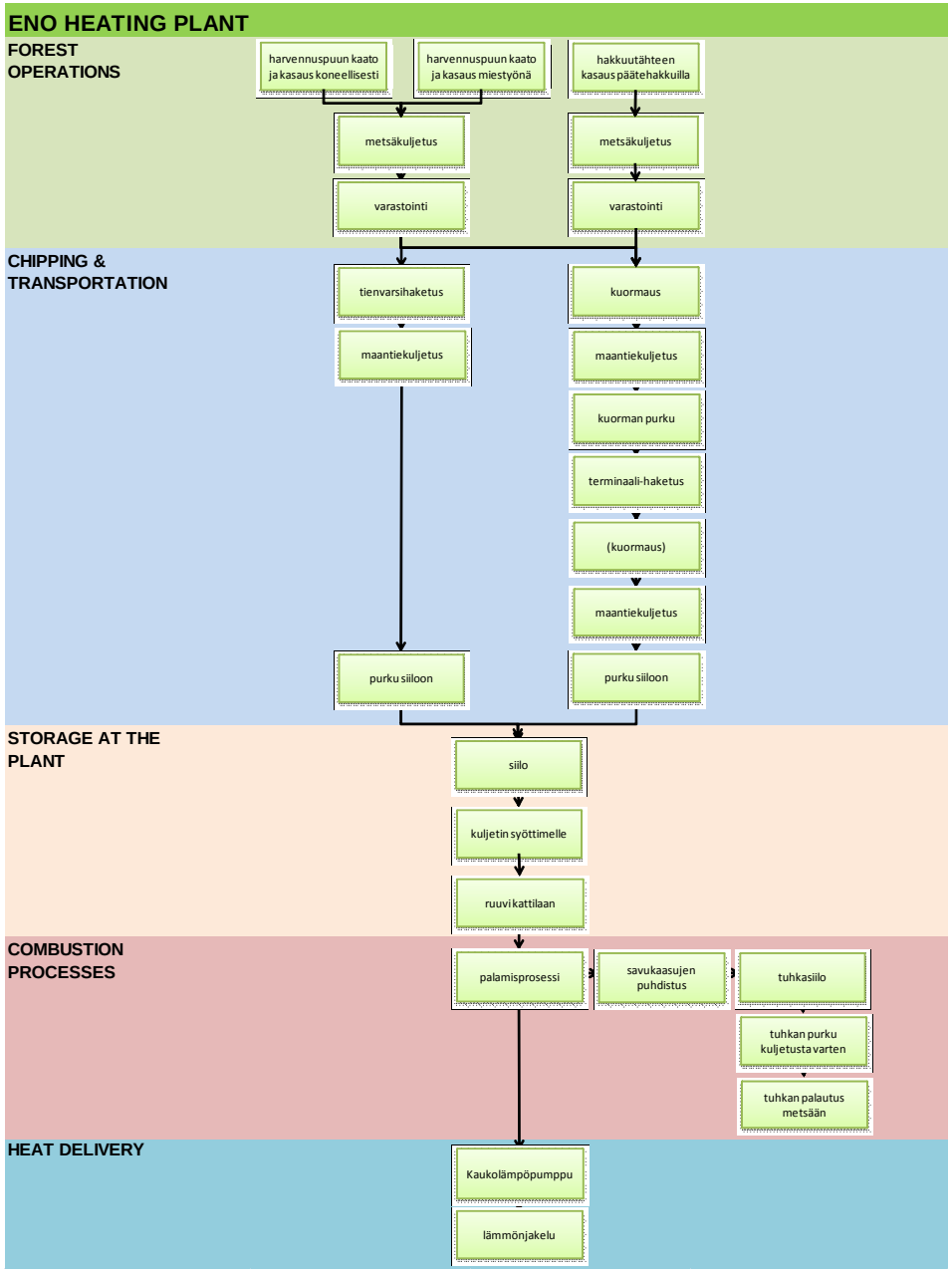


Practical assessment

- Literature review on existing criteria and indicators
- Expert interviews within the MCDA framework to define the fundamental indicators and their relative importance
- Building of production chain process descriptions
- Data gathering for life cycle inventory analysis
- Implementing interest group interviews as a part of life cycle impact assessments

Functional unit = MWh of raw material used

→ All the indicator data should be gathered in respect to the functional unit


ENO HEATING PLANT
FOREST OPERATIONS
harvennuspuun kaato ja kasaus koneellisesti
harvennuspuun kaato ja kasaus miestyönä
hakkuutähteen kasaus päätehakkuilla
metsäkuljetus
varastointi
metsäkuljetus
varastointi
CHIPPING & TRANSPORTATION
tienvarsihaketus
maantiekuljetus
kuormaus
maantiekuljetus
kuorman purku
terminaali-haketus
(kuormaus)
maantiekuljetus
purku siiloon
purku siiloon
STORAGE AT THE PLANT
siilo
kuljetin syöttimelle
ruuvi kattilaan
COMBUSTION PROCESSES
palamisprosessi
savukaasujen puhdistus
tuhkasiilo
tuhkan purku kuljetusta varten
tuhkan palautus metsään
HEAT DELIVERY
Kaukolämpöpumppu
lämmönjakelu

Ecological indicators

- emission to air (GHG, hazardous gases, fine particles)
- emissions to water (N, P, solids)
- emissions to water (nitrogen, phosphorus and solid material) and atmosphere (GHG, other hazardous gases, fine particles)
- soil nutrient balance
- energy balance (fossil fuels/total usage of energy)
- consumption of water
- net amount of waste produced after recycling

Economic indicators

- revenues from sales
- turnover
- profit from the production
- value added during the process
- production costs
- net employment generation
- efficient usage of forest biomass resources (capasity vs. potential)
- income for the employed people

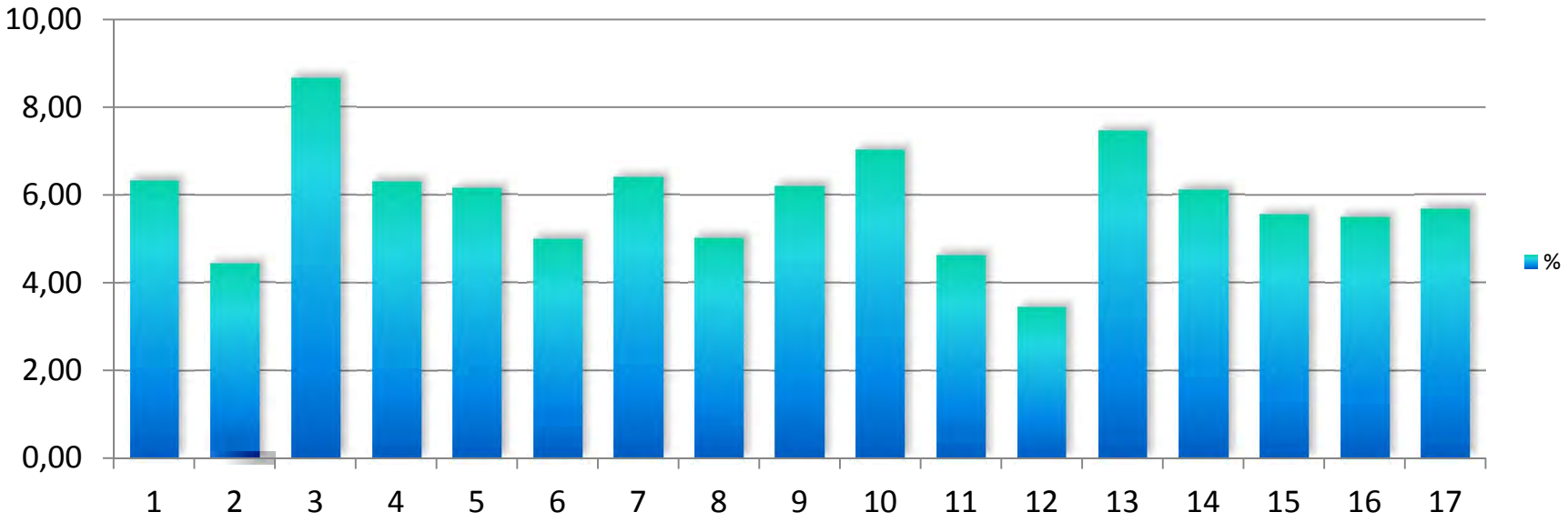
Social indicators

- existence of networks disseminating social capital in the region
- possibilities for different stakeholders to affect decision-making processes
- proportion of local ownership of the enterprises
- equality between generations
- proportion of women of the workforce
- occurrence of work-related accidents and illnesses
- opportunities for new employment generation
- institutional support for production systems
- aesthetic harms for local people
- “every mans” rights

Cultural indicators

- Acceptability –"Ways of operations must be acceptable and suit with the values in the society"
- Stump harvesting – "Stump piles are unaesthetic and frightening"
- Technology usability – "Applicability, efficiency and learn ability of technologies"
- Locality – "Both the raw material and the usage of products should be local"
- Recreational use –" Usage of energy wood may change species of game, mushrooms and berries as well as the way people experience the forest area"
- Peat production areas – "New peat production areas destroy cultural landscape"

Importance of indicators



	Ind 3	Ind 13	Ind 10	Ind 7	Ind 1	Ind 4	Ind 9	Ind 5
Expert 1	0,06	0,07	0,05	0,06	0,07	0,07	0,07	0,06
Expert 2	0,12	0,09	0,10	0,08	0,09	0,07	0,03	0,03
Expert 3	0,07	0,07	0,06	0,05	0,04	0,04	0,06	0,07
Expert 4	0,08	0,06	0,06	0,06	0,05	0,05	0,06	0,06
Expert 5	0,10	0,06	0,06	0,06	0,03	0,08	0,07	0,06
Expert 6	0,09	0,09	0,09	0,07	0,09	0,06	0,08	0,08
Avg	0,09	0,07	0,07	0,06	0,06	0,06	0,06	0,06
% of total	8,68	7,47	7,03	6,40	6,34	6,32	6,21	6,15

Calculation tool

- Indicators, their importance and indicator data collected from unit processes are implemented as Excel tool.
- User can select what indicators are taken into consideration and what are their importance values
- By changing the importance of sustainability dimensions, decision maker can easily see how different production chains are performing in respect to selected indicators and dimensions

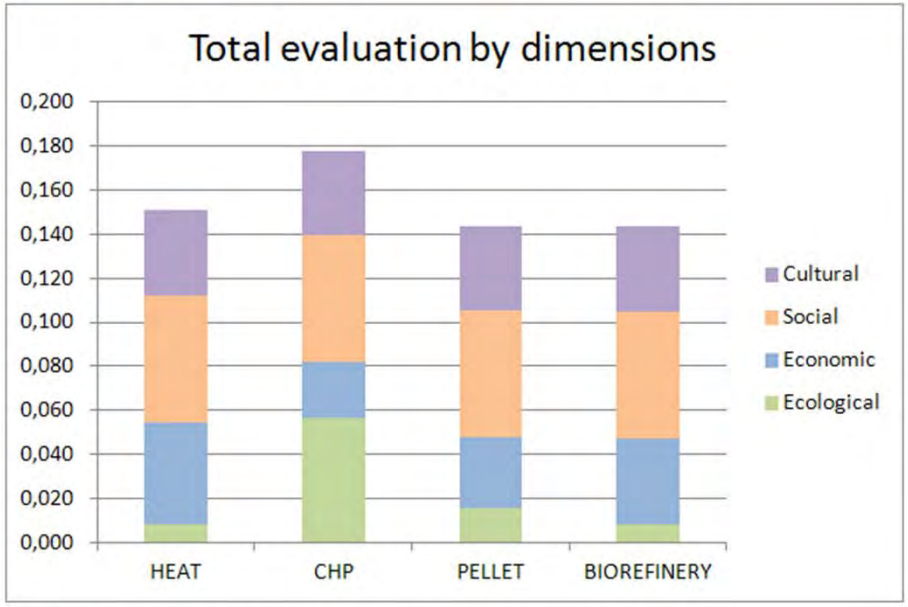
BioSus demo - Microsoft Excel

Aloitus Lisää Sivun asettelu Kaavat Tiedot Tarkista Näytä Apuohjelmat Acrobat

BioSus

Importance of dimensions

60	100	60	40
Ecological	Economic	Social	Cultural



Results with given importance values

HEAT	CHP	PELLET	BIOREFINERY
0,151	0,178	0,144	0,143

Etusivu Vaihtoehdot INDIKAATTORIT JA PAINOKERTOIMET Ekol. TIEDOT Ekon. TIEDOT Sos. TIEDOT

Valmis 120%

Conclusions & findings

- It is important to take into account the regional characteristics when assessing the social sustainability of bioenergy production
- Listing the indicators is not enough – information of the relative importance/value/criticality of different indicators is needed (MCDA)
- In addition to indicator definition, it is crucial to receive valid, reliable and quantified data on socio-cultural sustainability – information is gathered from local people and company managers: Final results by the end of 2011
- Functional unit in the BioSus-assessments is MWh – what is the interpretation in regard to social or cultural sustainability measurements?

KNOWLEDGE

Know-how

METLA

Thank you

Well-being

Forest