Assessing potential impacts on biofuel innovation on regional sustainability transition: A case-study in Innlandet, Norway

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Introduction

- EBIO focus
  - Electrochemical conversion of pyrolysis oil and black liquor, into green fuels, platform chemicals and high-added value compounds
- SIA combining quantitative and qualitative analysis
- Case-based Approach
  - Standalone pyrolysis unit w. electrochemical upgrading in a region with sawmills (Innlandet, Norway) – capacity 40 000 tons of biomass/year
  - Considering the whole value chain
  - Alternative scenarios
- RQ: What are the potential social impacts of implementing a value chain for production of advanced biofuels using EBIO technology in the selected case region?

Existing pyrolysis plant in Gävle, Sweden, with capacity 40 000 tons of biomass per year. Source: https://www.btg-bioliquids.com/plant/pyrocell-gavle-sweden/

Background

- Lack of an established, authoritative method for social sustainability assessment
- Emphasis on potential for regional development in bioeconomy
- Critical perspectives (e.g., Allain et al., 2022, Bringezu et al., 2021)
- Call for new and better assessment methods, taking a system perspective
- Need to define approach in dialogue with stakeholders (e.g, Falcone et al., 2019)
- And, taking context into account

Methodology

- Literature review
  - 2021-2022, 45 studies
- Baseline study on bioeconomy in Innlandet county
- Stakeholder involvement in selection of impact categories and indicators
  - 6 evaluation criteria
  - 1 physical and 1 online workshop
  - From 60 to 32 indicators
- Input-output modelling (MEIONorway – Aponte et al., 2021, Wiebe et al., 2023)
- Focus groups with local stakeholders
- Still in process

Location and extent of Innlandet county, Norway.
Source: Google Maps.

Assessment framework

- Main categories from S-LCA (UNEP-SETAC, 2009; UNEP, 2020)
- Added indicators:
  - **Value chain:** Skill mix, substitution, potential adopters, incentives
  - **Users:** Social acceptability, fit with existing systems and practices, incentives
  - **Region/local community:** Innovation capacity, economic attractiveness, bequest value
  - **Wider society:** Contribution to renewable energy mix, secure supply of biofuel, alignment with national decarbonisation strategies, contribution towards circularity

	Impact category	Subcategories	Indicators
Value chain	Competence	Skill mix	Job requirements by qualification
	Competi-tiveness	Potential adopters	The number of enterprises that may adopt the process technology
		Substitution of non-sustainable products	The types and volume of non-sustainable products on the market that the end-product can replace
		Incentives for early providers	The extent to which biofuel production is incentivised
	Governance	Transparency	The extent to which strategic plans, annual reports, sustainability reporting, etc. from the involved enterprises are publicly available
		Traceability	The extent to which the origin of the input factors can be traced and managed
Workers	Health and safety	Health and safety of workers	The percentage of workers that are exposed to dust, gas or steam most of the time The percentage of workers that are exposed to skin-irritating substances most of the time The percentage of workers that have a high risk of accidents
	Human rights	Gender equality at work	The male/female wage ratio The male/female employment ratio
	Labour rights and decent work	Fair wages	Wages for each part of the value chain compared to minimum wage
		Unionisation	The share of workers organised in trade unions
		Meaningful work	The percentage of workers that are required to often or always work at a high pace. The percentage of workers that will often or always be required to acquire new knowledge and skills.
Users	Social acceptability	Fulfilment of formal sustainability criteria	The extent to which the end-product meets sustainability criteria laid down in relevant regulations
		Willingness to pay	The maximum price consumers are willing to pay for one unit of the end product
	Usability	Ease of use	The extent to which the end-user needs to modify user equipment or practices
	Availability	Incentives for users	The extent to which the use of the end-product is incentivised
Local community	Contribution to local economy	Value creation	The expected gross product of the economic activity related to implementation of the solution
	Quality of life	Employment	The expected number of new employees resulting from implementation of the solution
		Bequest value	The level of satisfaction from preserving the natural environment for future generations
	Innovation capacity	Contribution to innovation clusters	The number of existing clusters expected to benefit from the initiative
		R&D activities	The number of R&D activities initiated in connection with the solution
	Regional attractiveness	Contribution towards realisation of regional development strategies	The extent to which implementation of the solution can contribute towards realisation of regional development strategies
		Regional economic attractiveness	The extent to which implementation of the solution can influence the economic attractiveness of the region
Wider society	Energy security	Renewable share of energy mix	The extent to which implementation of the solution will increase the renewable share of the energy consumption
		Secure energy supply for transport	The extent to which implementation of the solution can contribute to securing supply of biofuel
	Food security	Use of arable land	The territory of arable land needed to produce the annual need for feedstock
	Sustainability transition	Alignment with national decarbonisation policies	The extent to which implementation of the solution is aligned with national policies for decarbonising the transport sector The amount of GHG emission the implementation of the solution can contribute to reduce
		Contribution towards circularity	The amount of waste the implementation of the solution can contribute to reduce

Preliminary results - employment and value creation

- Fuel: Positive overall effect on the economy, largest value chain effects in forestry and wood industry, expected to benefit Innlandet in particular
    - Direct employment: 13.5 employees
    - Indirect employment: 105.6 employees (2040)
    - Value-added: 255.3 MNOK (2040)
- **Increased benefits if by-products in form of platform chemicals are included**
- Negative impact on petroleum-related sectors
- Limited impact on human rights and workers, positive score for fair wages, and possible risks in terms of male/female employment and opportunity for acquiring new knowledge and skills

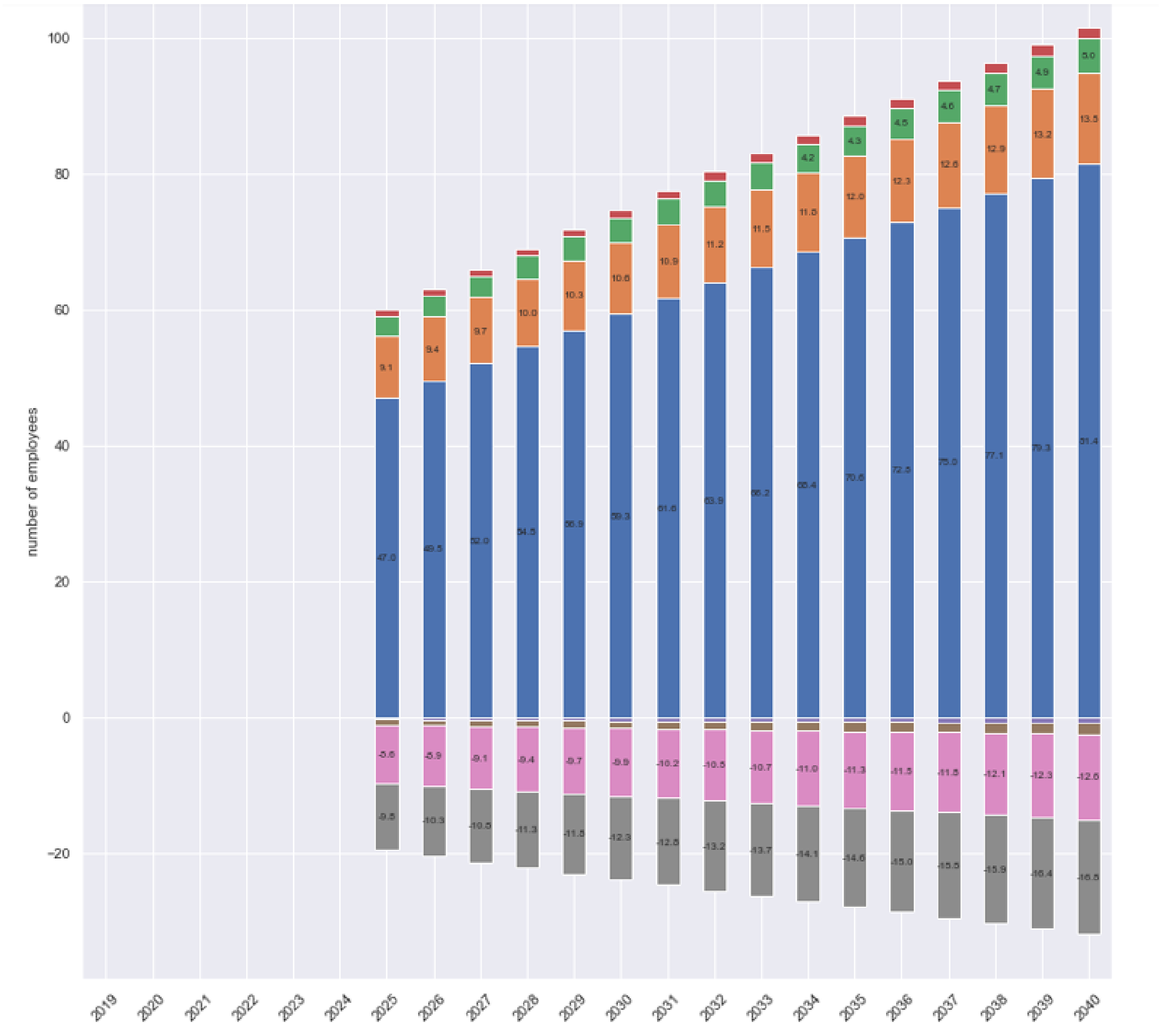

Figure 7: Employment value chain effects for top four and bottom four sectors. Numbers are for scenario1 relative to scenario0

Preliminary results – regional innovation and attractiveness

- Several potential adopters of the production technologies
  - Big sawmills
  - Existing pyrolysis plant (heating and biochar)
- Presence of incentives
- Four clusters likely to benefit from the initiative
- New R&D activities
- Significant contribution to regional skill mix (current lack of chemistry competence)
- Potential increase of economic attractiveness (patents, connectedness)
- Potential benefits in terms of bequest value, though potential future debate over industrial vs. more socio-ecological practices in forestry

Preliminary results – wider society

- Aligned with national decarbonization strategy (however, somewhat unclear signals and strong focus on other alternative fuels)
- Small, but important contribution to the national mix of sustainable, renewable energy solutions
- Modest, but significant contribution towards reducing current import dependency of advanced biofuel and shifting from B- to A-feedstock type
- No use of arable land – low ILUC risk, positive impact in terms of replacing biofuel from feedstock conflicting with food production in other countries
- Closing and localizing resource loops while increasing value creation from residues/reducing waste

Discussion and conclusion

- Biofuel production based on wood residues and electrochemical upgrading of pyrolysis oil may have positive impacts both at a regional level and in a global perspective
- Flexibility – scalable, and can substitute for several fossilbased products (platform chemicals of higher value)
- Social impacts are influenced by the pre-existing context, as well as the technological solution
- Mixed methods provide a broad, systemic perspective – indicators of different quality are needed
- Limited availability of data remains a challenge
- SIA may be useful, guide technology development as well as management
- Further refinement of indicators and assessment methods are still needed

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Thank you!

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