



Zero Waste Ligno-Cellulosic Bio-Refineries

Techno-economic evaluation and social impact assessment as tools for the feasibility decision of an integrated biorefinery

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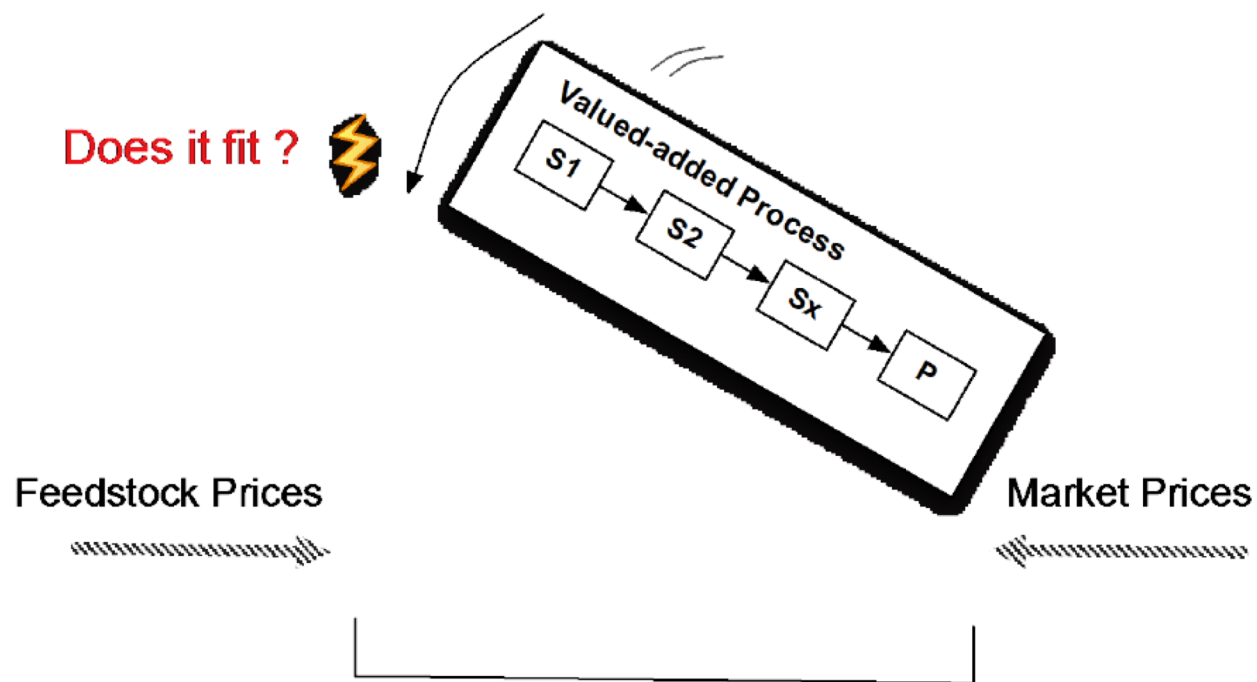
The TEE is an assessment that needs to be harmonised with the LCA

- on methodology, system boundaries, goal and scope
- on production processes, units, allocation and reference products
- on the data collection process

All these topics were discussed already in the presentation of Xun Liao, so in this presentation we concentrate on the specific TEE



TEE – the fundamental question...



The base of the techno-economic evaluation

- ✚ TEE assesses technological and economical aspects of a process/product
 - ✚ Different types depending on TRL (Technical Readiness Level)
 - ✚ Technological aspect:
 - ✚ Process
 - ✚ Product
 - ✚ Economical aspect:
 - ✚ Costs
 - ✚ Market Analysis & expected Benefits



ZELCOR TRL: From lab to commercial scale

Technical Readiness Level



1 (lab scale)

to



10 (commercial scale)



Technological Aspect: Process & Product

 Example: Production of Antioxidants from Lignin

 Process is visualised:

 In a Sankey Diagram

 In a table (energy & feedstock input)

 Product is described:

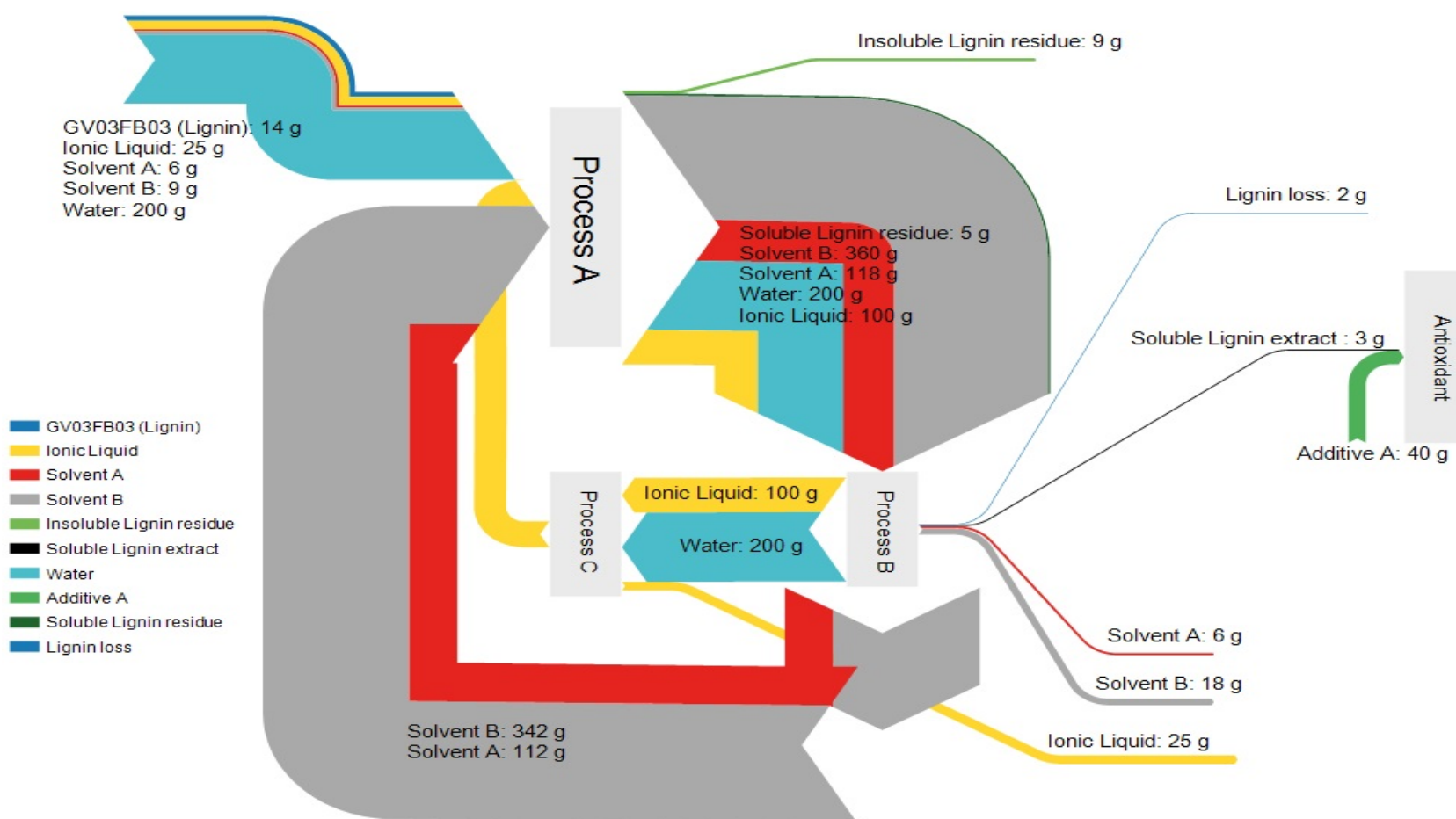
 In a pie chart (cost structure)

 In a text (properties & application)

Economical Aspect: Market Analysis



Technological Aspect: Process: Sankey Diagram





Technological Aspect: Process: Table

Amount of GV03 lignin used (kg)	Amount of antioxidants produced (kg)	Necessary energy (kWh)	Cost of electricity for non-household consumers (€/kWh)	Energy costs for the process (€)
1	0.21	5.74	0.12	0.69



Technological Aspect: Product

Properties:

-  Antioxidant
-  Antimicrobial



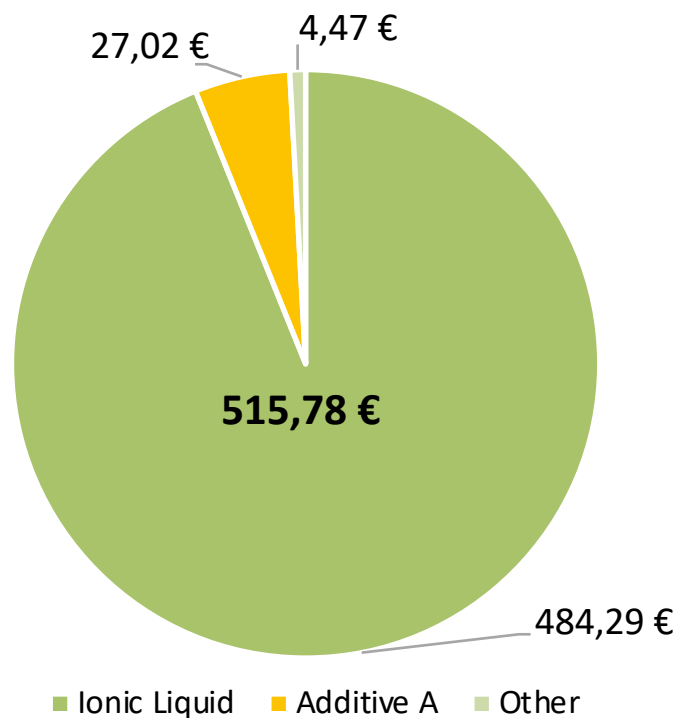
Application:

-  Cosmetics
-  Plastics



Economical Aspect: Costs for the production of 1 kg in optimised lab scale


Cost structure



Economical Aspect: Market Analysis & expected Benefits

-  Comparable to a large number of similar products

-  Depends on specific properties & application of the Zelcor product

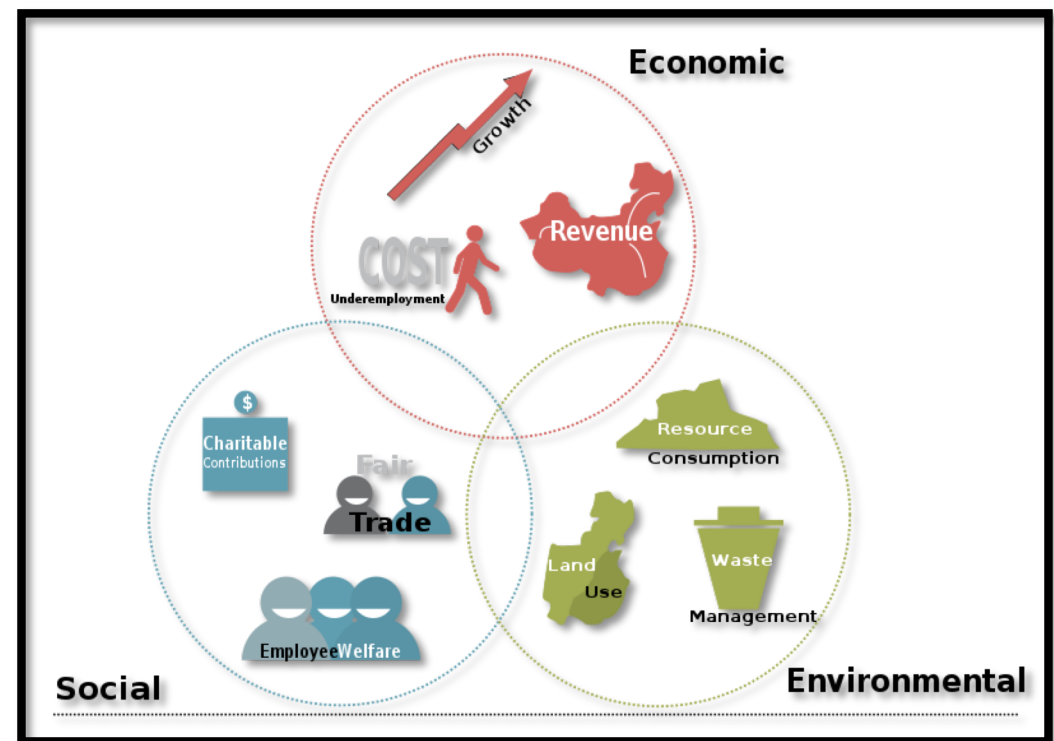
 -  OIT: Oxidation Induction Time (Measurement of the time of a material to be stable against oxidation in a calorimeter)

 -  Application: Research vs. Commercial

-  Price from comparable products ranges from 2,50 €/ kg to 800.000 € /kg – what is the real market to adress?



- 🐛 Social aspects are an often overlooked aspect of sustainability, but forms together with environmental and economic aspects the Triple Bottom Line
- 🐛 Basic idea is to consider the people and whether practices are fair and beneficial towards labour, the community and the region.
- 🐛 In ZELCOR at the current TRL, a SWOT analysis was considered as feasible approach to capture relevant social impacts



Some areas of study of the Triple Bottom Line framework
(source: [Wikipedia](https://en.wikipedia.org/wiki/Triple_bottom_line))




 SWOT: tool to assess the performance of a project

	Success factors	Failure factors
Internal	Strengths	Weaknesses
External	Opportunities	Threats

Structure of a SWOT matrix (Kretschmer, Schröter et al. 2013)

Things that Zelcor does well and separate it from other competitors	Things that Zelcor is lacking, where alternatives might do better
Elements in the external environment that can increase integrity and profitability of Zelcor	Elements in the external environment that can endanger the integrity and profitability of Zelcor

 In order to capture all relevant social impacts, the biorefinery concept, the products of ZELCOR and the project itself were investigated

 Product level: guidance from S-LCA (social life cycle assessment)

 Project & refinery level: guidance from SIA (social impact assessment)



Stakeholder categories	Subcategories
Stakeholder “worker”	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and Safety Social Benefits/Social Security
Stakeholder “consumer”	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility
Stakeholder “local community”	Access to material resources Access to immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions
Stakeholder “society”	Public commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption
Value chain actors* not including consumers	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights


BOX 2. Indicative thematic sections for an SIA

1. **Regulatory framework** (relevant international standards, national/regional legislation, sector specific legislation, customary law)
2. **Administrative divisions and governance structure** (national, regional, local levels of governance, international relations)
3. **Population/demographics** (gender/age/ethnicity, migration trends, religion, vulnerable groups)
4. **Economy** (employment, key sectors, business environment, financial services institutions, labour rights/working conditions, informal livelihoods, income, poverty/inequality)
5. **Infrastructure** (utilities, electricity, telecommunications, waste management, housing, transport infrastructure, markets/trade links, recreational facilities)
6. **Community health, safety and security** (health of population, mortality rates, health services, water/sanitation, road safety, fire services, disaster management services, police/security services, access to justice)
7. **Education** (literacy, education levels by gender, education and training institutions/services)
8. **Social problems** (crime, alcohol/drugs, prostitution, child/forced labour, employment inequalities, social tensions and conflict)
9. **Land tenure and use** (types of land and natural resource use, water use and availability, private/customary forms of use and ownership, types of agriculture/livestock ownership)
10. **Cultural heritage** (archaeological finds, indigenous sacred sites, historical buildings)
11. **Civil society** (trust, civic involvement, press freedom, freedom of association, civil society activism, trade unions, mass media, social media, indigenous rights groups, environmental groups, non-governmental community support organisations)

Indicative list of topics for an SLCA (UNEP, 2009) and for an SIA (Wilson, 2017)

Identifying SWOT for social impacts of ZELCOR

Steps included

-  Literature study (on SIA, on SLCA, on other projects e.g. BIOCORE)
-  Project-internal workshop in Marseille
-  Expert interviews



Outcomes of the social impact SWOT workshop in Marseille



SWOT results on project / refinery level

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> • Local employment • Regional economic development • Utilization of (local) by-products or waste streams • Safer working conditions • Skills and knowledge in region and Europe • Collaboration between academics and industries 	<ul style="list-style-type: none"> • Infrastructure requirements • Water demands • Power / Energy demands • Transport & storage • Land use • Biomass utilisation • Sealed area • Risk of failure / long way to commercialisation
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • Integration into existing refinery / Retrofitting • Integration with existing infrastructure • Technology transfer • Regional specialisation in lignin or waste valorisation (additionally education) • Trend to investment / funding on novel environmental technologies • Transformation of economy (from fossil to renewable) • Regulation pushing lignin / insects 	<ul style="list-style-type: none"> • Infrastructure insufficient (waste collection / water / renewable energy / transport) • Public rejection of biorefinery • Waste & mass insects in neighbourhood • Noise, smell, pollution • Risk of invasive species • Regulation inhibiting insect / lignin utilisation • Lack of experience in insect rearing

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> • Innovative production routes / value chains • No food competition • Replacing fossil-based products • Reduce dependence on resource imports • Cascading use & circularity • Health and safety • Integrated value chains • More sustainable (check with LCA) 	<ul style="list-style-type: none"> • High environmental impacts (check with LCA) • Complex value chains • Not competitive yet
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • Demand for products from waste / insects • Establishing new value chains from ionic liquids and nanoparticles • Increased enforcement of circularity and waste stream utilisation • Fossil feedstocks increase in price 	<ul style="list-style-type: none"> • Public rejection of products from waste / insects (also used as “insect mining”) • Unfair competition with fossil feedstocks • Supplier dependency (only 1 humin producer) • Uncertainties in e.g. waste management • Product specific regulation

ZE^{EL}COR Detailed look: Local employment and rural/regional economic development (Strength)



- 🐜 Local employment will be strengthened by the construction of a biorefinery
 - 🐜 Installation of a new biorefinery (or retrofitting of an old one) will create employment opportunities for the local region and strengthen income generation for local farmers, adding to their job security
- 🐜 Biorefineries are likely to be constructed in rural areas, leading to more money circulating in the region and supporting economic development
 - 🐜 Rural areas often struggle economically due to people moving into metropolitan areas
 - 🐜 Additional revenues for feedstocks, additional revenues from biorefinery products
 - 🐜 Additional taxes, higher income of locals (who often spend locally)



Thanks for your attention



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