



TECHNO-ECONOMICS OF THE SEAWEED VALUE CHAIN

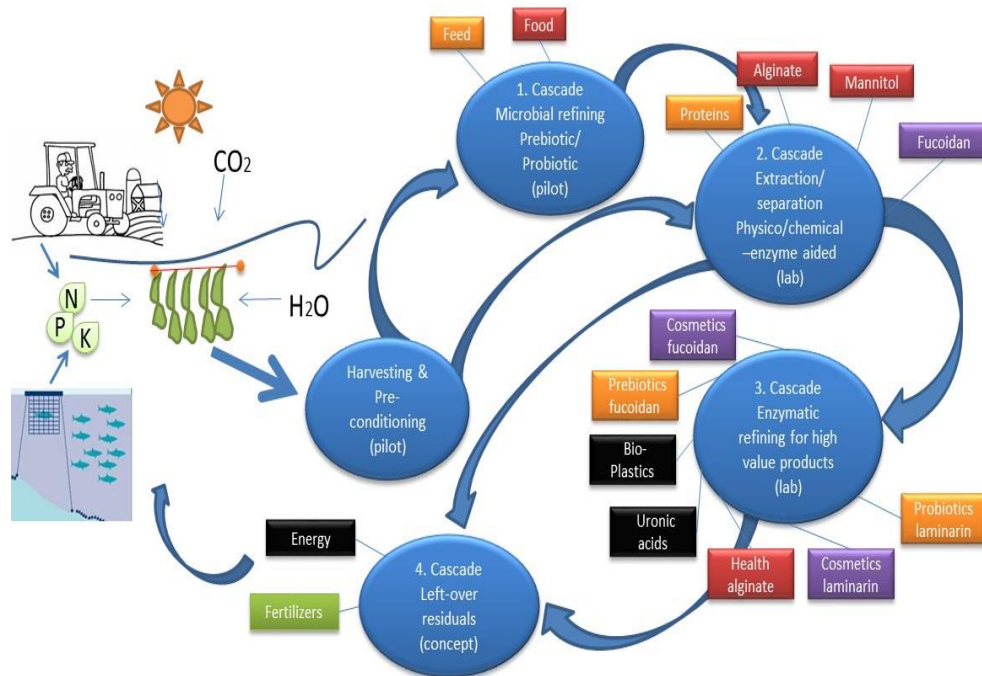
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MacroCascade Final Conference



Introduction



Results for value chains representative for Macro Cascade

Focus on full industrial scale

- Technical feasibility
 - Technical design, mass balance, heat demand
- Cost drivers
 - OPEX, CAPEX and revenue drivers

Very early stage of development

- High level of uncertainty
- Information on the feasibility is limited given improvement potential

Value chains

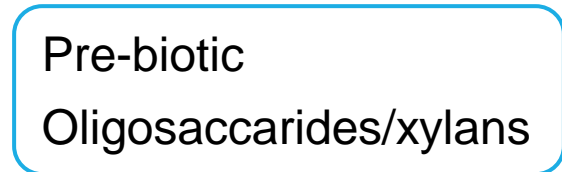
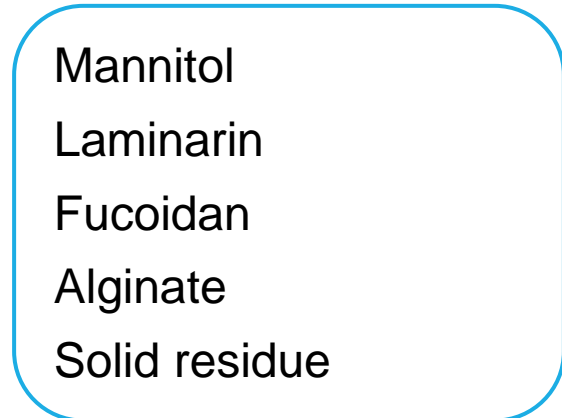
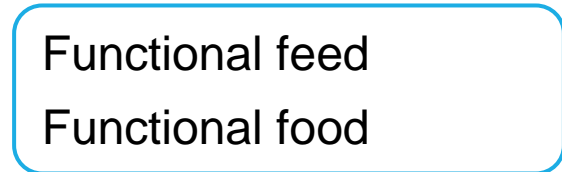
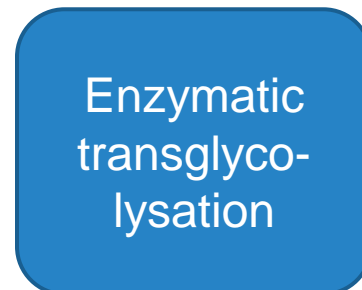
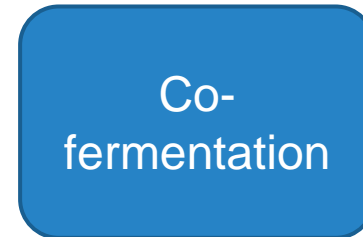
Cultivation



Preservation/ storage

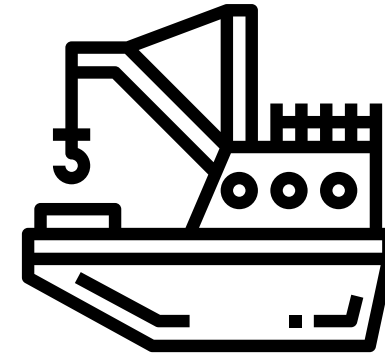
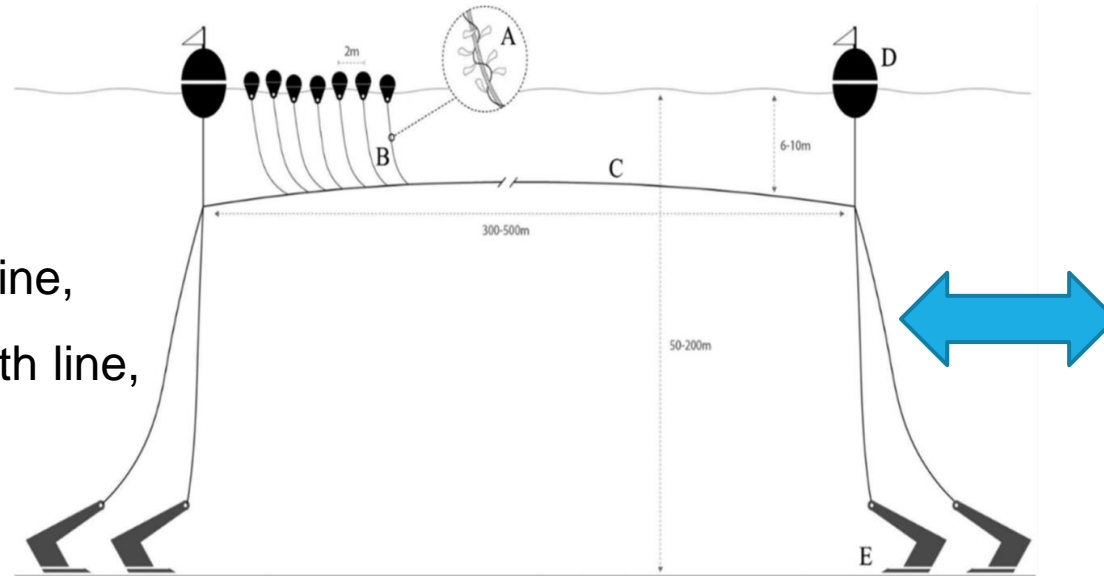


Valorisation



Cultivation, design

- 2,200 km of fixed line,
- 11,000 km of growth line,
- plot area 7x7 km



Technical design

Successfully designed upscaled version of the demonstrated cultivation system

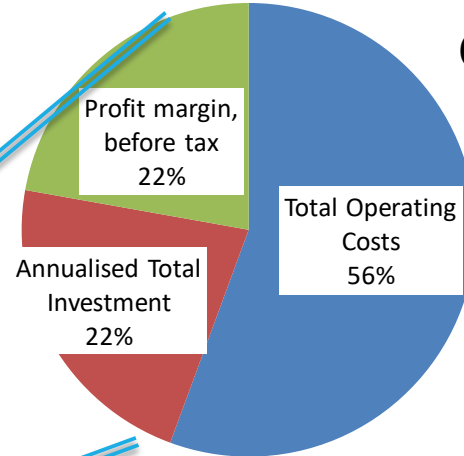
Logistics design

Mapping of seeding and harvesting logistics

Drivers → Yield is the most important parameter

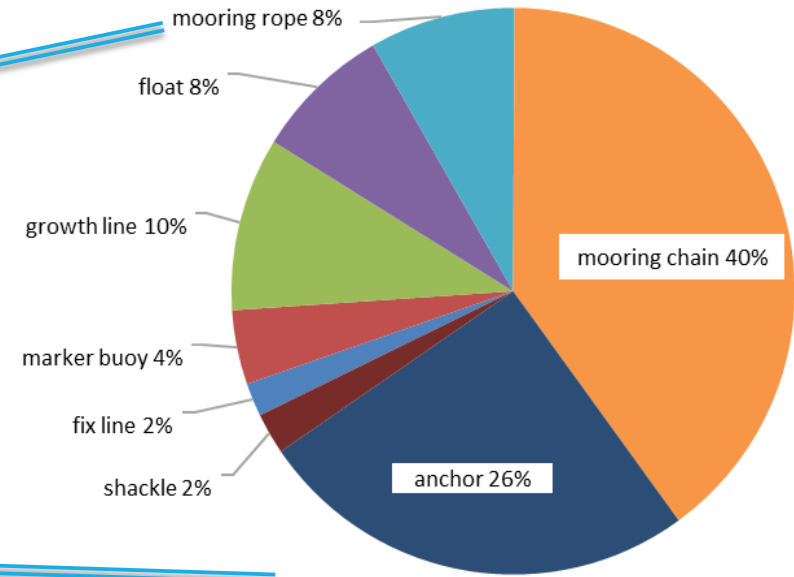
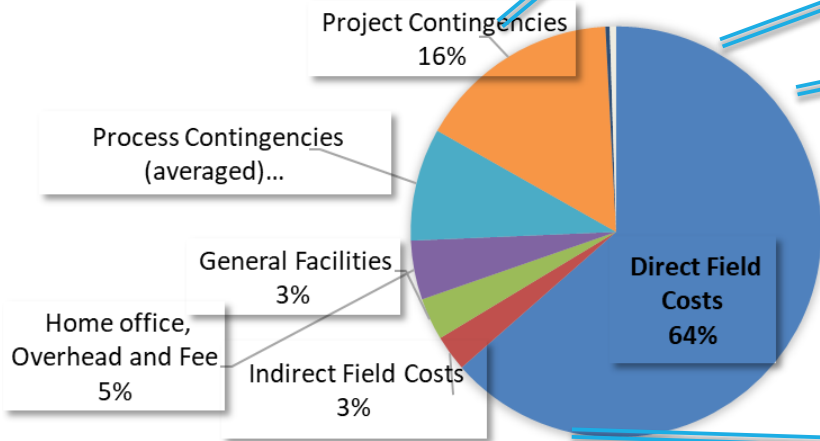
Cultivation, cost drivers

Cost-plus price



CAPEX

Direct field costs



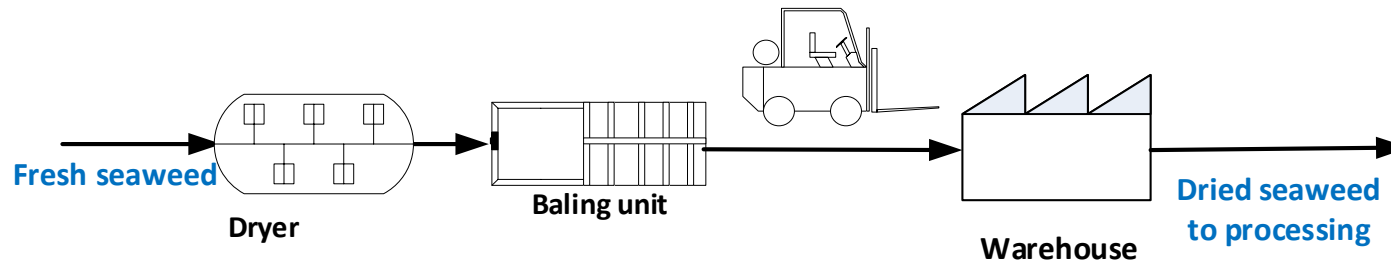
Cultivation, conclusions

Conclusions

- Successful upscaled design for 10 ktonne_{dw}/yr
- Not dictated by a single cost element, many cost elements including indirect costs
- Many uncertainties, important are growth yield and industry architecture (leanness)
- Future improvements and innovations (e.g. underwater harvesting) will reduce costs
- Cost are significantly higher than wild harvest seaweed, so focus on high-revenue applications

Preservation and storage

Drying



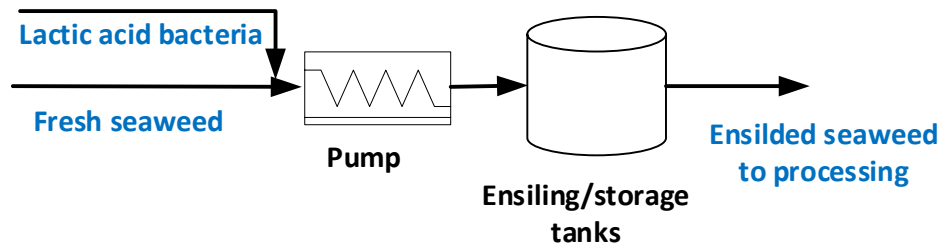
Technical

Simple, but limited knowledge on upscaling

Economic

Low CAPEX
High OPEX

Ensiling



Technical

Uncertainty/risk in controllability and interaction with downstream

Economic

High CAPEX
Very low OPEX

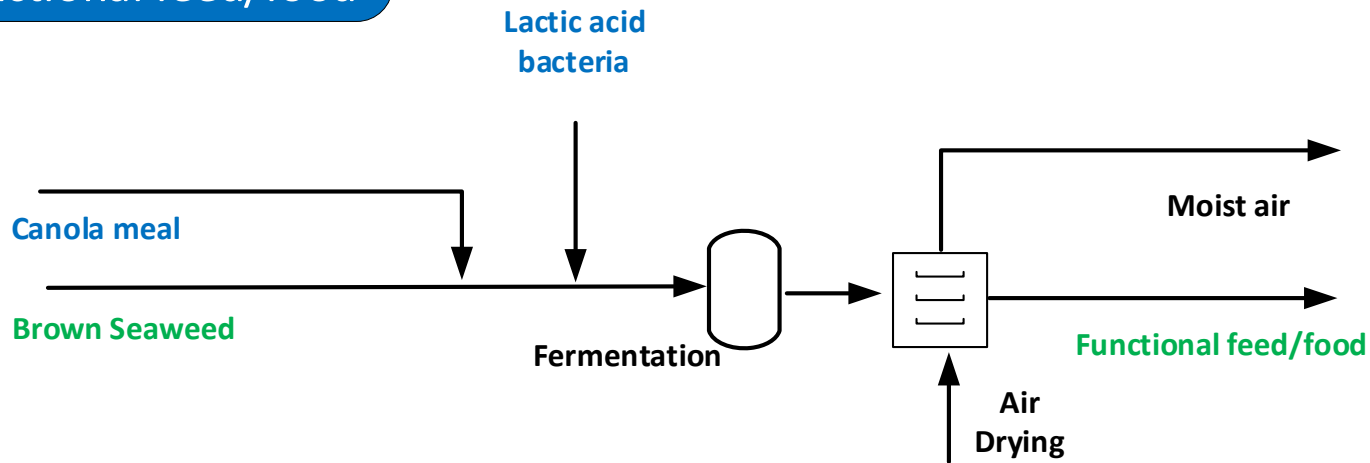
Conclusions

Storage can add up to 10% of the costs

- Ensiling is more economic
- Limited knowledge on effect of target components

Functional feed/food

Functional feed/food



Technical:

Simple and proven process

Economic:

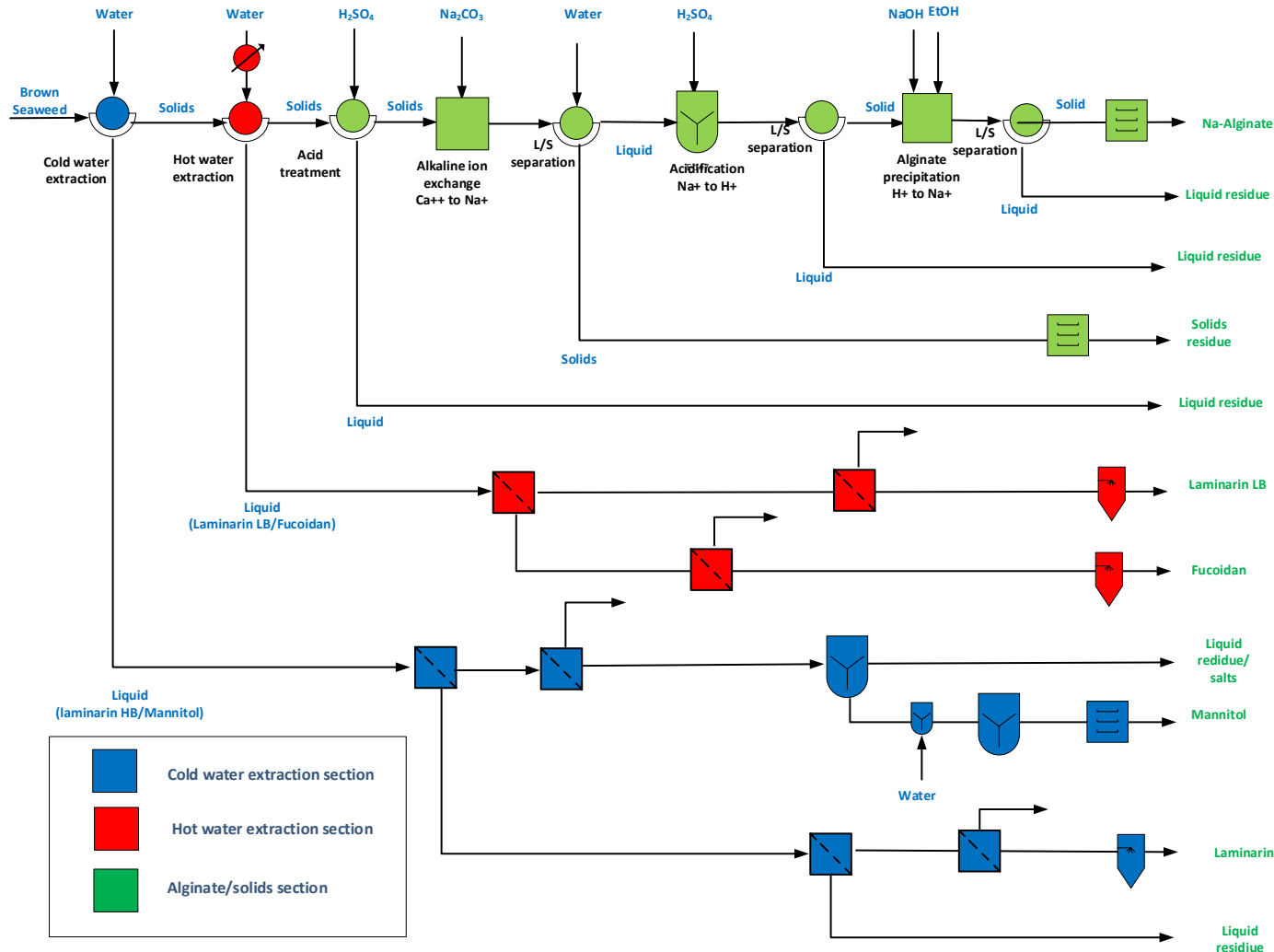
OPEX: canola meal and seaweed
 CAPEX: limited contribution

Conclusions

Functional feed:
 Good case with feasible economics

Functional food:
 Higher costs (food grade) but potentially very high revenues

Fractionation



Mannitol
Laminarin
Fucoidan
Alginate
Solid residue

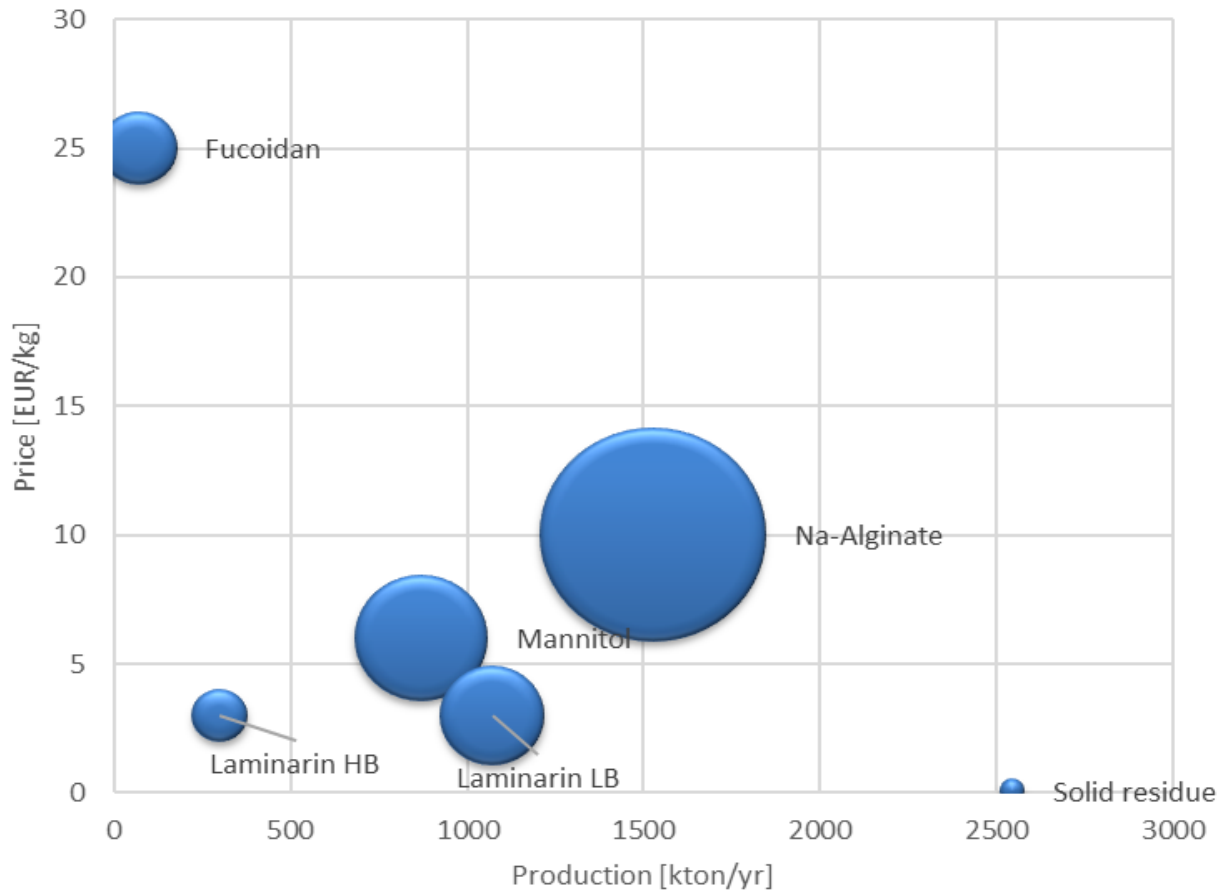
Technical:

Complex scheme, many steps
 • 25 step, 45 pieces major equipment
 Optimal use of all constituents

Many operations to be verified

- Extraction yields
- Membrane separations
- Crystallization/purifications
- Interactions

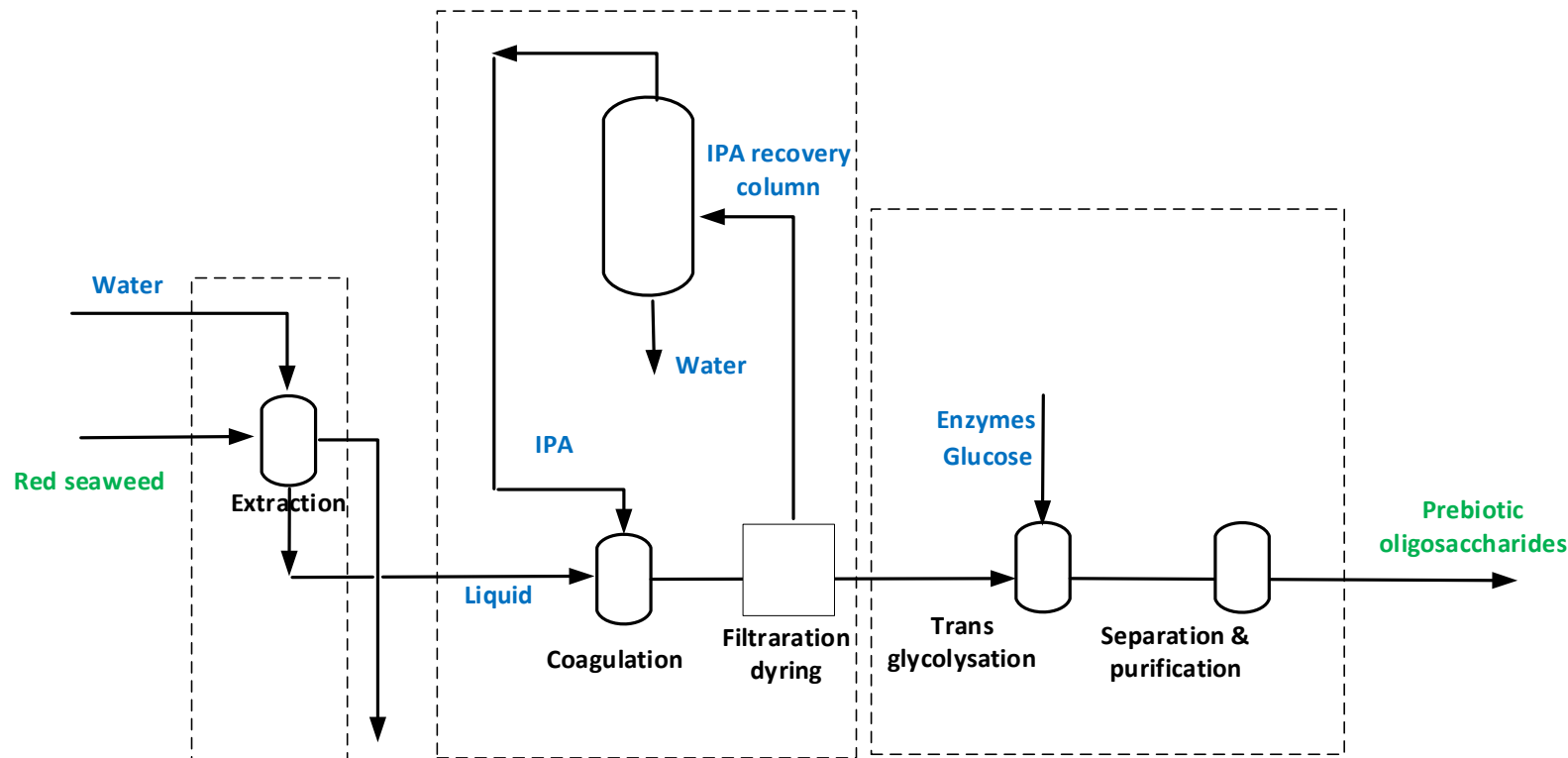
Fractionation



Economics

- All products contribute to the revenues, except for the solid residue
- Significant investment
- Find balance between investments and product revenues

Pre-biotic oligosaccharides



Extraction Coagulation/recovery Transglycolysation

Technical

- Feed is red seaweed
- Heat use for recovery of extraction solvent
- Ideas for alternative schemes and processes (membrane separation)
- Final enzymatic step is optional, adds little to the costs

Economic

- Very good yield in oligosaccharides
- Heat use very high
- Revenues: Sales value of probiotics is very dependend on their efficacy

Conclusions and outlook

Cultivation is feasible, scalable: lean operation and costs reduction

Storage: Ensiling less expensive, lower energy use but more uncertain

Fermentation to feed and food

- Feed is the best short-term option
- Food potentially very good

Fractionation

- Increased income confirmed, need to find a balance between revenues and complexity/costs

Oligosaccharides/xylans

- Alternative separations essential for feasibility
- Efficiency of oligosaccharides important for value.

Results are an important step towards realizing seaweed value chains and also feedback into the research

Acknowledgement



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<https://www.macrocascade.eu/>