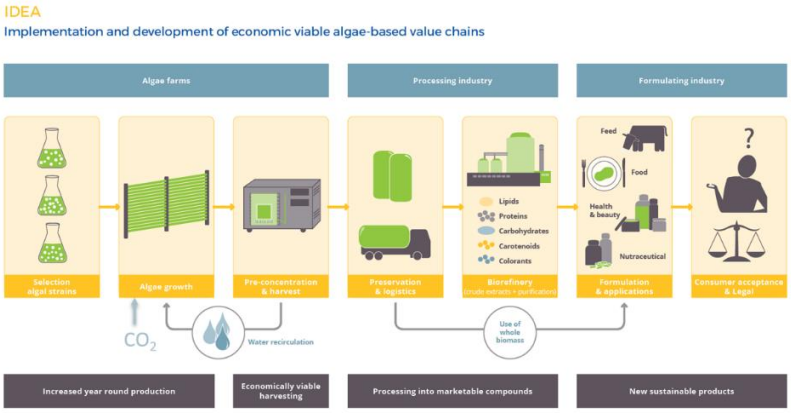
IDEA Position paper –

Logistic aspects of algae-based value chains

Within the Interreg NWEurope IDEA project, the enrollment of algae values chains in Europe was investigated. IDEA supported the early stage address of logistic and value chain configuration assessment when setting up new and innovative biobased value chains. IDEA focused on (1) geographic mapping of potentials, (2) establishing of logistic blueprints for future chains, (3) with attention for cooperation, (4) while addressing the complete value chain. This document summarizes the views of the IDEA consortium on several questions related to the logistic aspects within algae-based value chains.

Which logistic aspects are relevant in algae-based value chains?

- **"Algae-based value chains"** refer to trains of activities that occur at:
  1) algae farm level,
  2) algae processing level, and
  3) product formulation level.
- At each level, logistic requirements are to be considered such as storage capacity, capacity of equipment, quality and type of the product, etc.



- The three levels are linked through transport operations between the locations with again their specific constraints on transport (e.g. cooled or not) and on algae product (degree of dewatering).

At what stage are algae-based value chain logistics to be addressed?

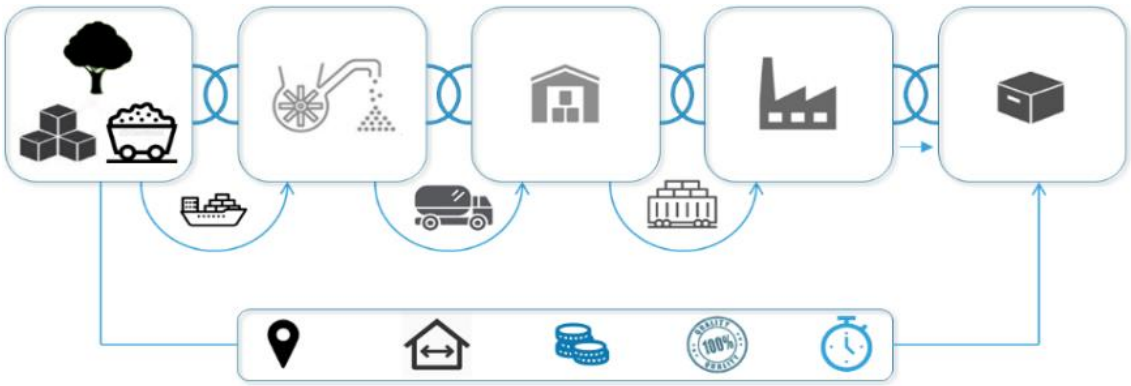
- The IDEA project ambitions to implement and develop economic viable algae-based value chains. While the algae-based sector is still in its infancy, the biologic and technical address of algae production and processing is rightfully so in the project focus. But also, algae-based value chain logistics are to be addressed at an early stage.
- IDEA committed to **early-stage** attention to the aspects of logistics and transport when sketching future value chain configurations in the North-West European region. Commonly these aspects are addressed in a later stage of value chain development or, in a worst case, even simply disregarded. Wrongfully so. Decisions made in the set-up of value chains will often have a long-lasting impact on its overall performance**.**
- Decisions on the location and capacity of algae growers, preservation and processing sites must be made with the awareness that all chain activities should be aligned, ensuring algae throughput capacity is synchronized to prevent chain block-ups. Specifically, for biobased chains such block-ups are more likely. As algae are biological life, growing cycles, failures and seasonality will cause production changes needing alignment with storage capacity and final processors.

How were algae-based value chain logistics assessed within IDEA?

- To address these value chain logistics questions in IDEA, a *customized and flexible approach was applied using* the MOOV value chain logistics optimization service. MooV defines, designs and optimizes any value chain logistics and finds the best chain configuration taking into account the needs and constraints of the value chain in scope.
- MooV is flexible in nature and customizable to capture value chain specifics related to locations, costs, capacities, time-effects,… Different configurations can be compared side-by-side bringing forward the impact of critical decisions on the value chain performance.

Algae-based value chain logistics need cost minimization over the full value chain

- In the MooV assessment, the objective was set to define value chain configurations at least global cost. The value chain stretching from the algae cultivator up to the gate of the algae processor. The global cost was defined as the sum of the capital and operation cost of (1) cultivation, (2) harvesting, (3) pre-concentration, (4) preservation, (5) downstream processing and (6) transport.

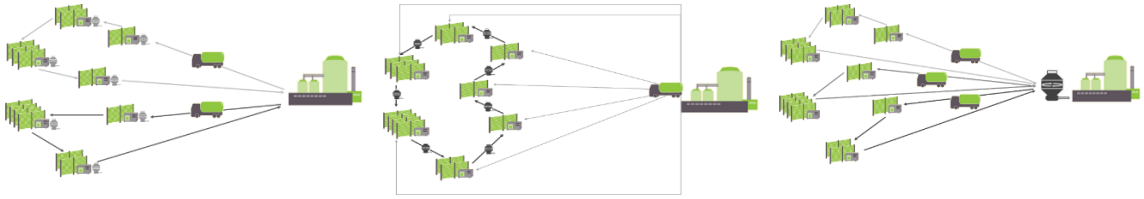


- Independent of the three differentiators referenced below, the cultivation total cost represents the majority of the global cost (at the level of the full value chain, including clusters, and therefore not representing the exact share for each individual actor). The share is high, which is to be expected for novel and innovative products. After all, from commercial scale viewpoint, algae production is still in its infancy. Nonetheless it can be expected that the relative share of the cultivation cost will decrease in medium term as a result of economies of scale and efficiency gains in the cultivation process. Alternatively, this will make the other cost components more prominent. It is in these components that costs related to the value chain logistics are reflected. Moreover, these logistics costs have a long-term impact spanning over years or even decades, making them potentially sleeping cost giants. That is exactly why early stage address of logistic and value chain configuration assessment is strongly advised.

- Within IDEA, the impact of three key logistic parameters was evaluated as examples, being:
  - The location of the dewatering centrifuge
  - The heating strategy for cultivation
  - The density of the cultivation network

What is the impact of the location of an algae dewatering centrifuge that is used after a first algae pre-concentration step?

- A centrifuge is a technology that is commonly used to harvest algae. In the IDEA scenario considered, algae are harvested via a two-step approach, being 1) a membranes-based pre-concentration step to remove 90-95 % of the water, followed by 2) a centrifugation step to further reduce the water content. For the latter step, different options were considered.
- Three alternative centrifuge locations were assessed; i) a fixed centrifuge at each individual cultivation site, ii) a shared mobile centrifuge making a weekly run, daily visiting one of the cultivation sites in a cluster of maximum seven cultivation sites and iii) a fixed centrifuge at the algae processing site.



Centrifuge fixed at each algae growth location | Shared mobile centrifuge | Centrifuge fixed at algae processing site

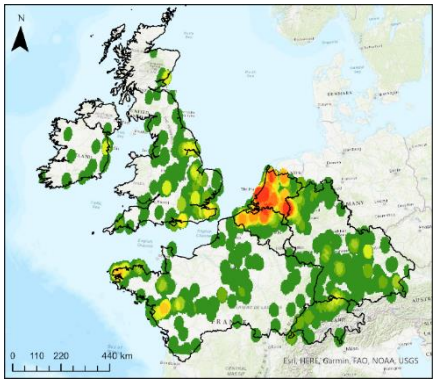
- The assessment resulted in the following findings:
  - Slightly contra-intuitive, the shared mobile centrifuge resulted in the highest transport cost. This because a truck must come to the cultivation cluster daily to collect the concentrated algae at each the cultivator site in the cluster once a week. The truck transport adds significantly to the overall transport cost making it the least performant option. Moreover, each cultivator needs a storage capacity of one week, awaiting the mobile centrifuge to pass by.
  - In contrast, a biweekly pick-up round along each cultivation site in a cluster is organized in the alternative with a fixed centrifuge, lowering the transport cost with a factor 4 to 10. The degree of reduction depends on the dry matter content of the algae product to be transported.
- With the centrifuge fixed at the processor, pre-concentrated algae are to be transported and a significant cooled storage at the farmer's site is required.
- Conclusions:
  - The centrifuge fixed at the cultivator's site has the lowest transport cost – a factor 10 lower than the mobile centrifuge scenario. It has the least storage needs while the collecting truck transports concentrated algae through a pick-up round along the cultivation sites in a cluster.
  - The collection of pre-concentrated algae and its transport to a central centrifuge at the processor resulted in a higher total cost (+10%) than in the scenario with a centrifuged fixed at every cultivator site, but it is economically more favorable for the algae farmer.

How does heating of the algae cultivation space impact economics?

- Two strategies were assessed:
  - Strategy 1: minimal growing temperature was safeguarded, leading to less heating cost but also less production.
  - Strategy 2: optimal temperature was attained leading to increased heating cost but also more production.
- Conclusions: Maintaining the optimal temperature resulted in the lowest global cost. The heating cost was found to be compensated by a reduced need for transport since less cultivators are needed due to the higher production in each cultivator.

Does network density of algae growers and roads matter?

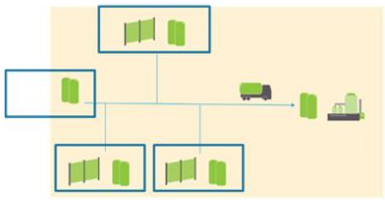
- Greenhouse locations were selected as candidate locations for algae growth in three regions (Flanders, Bayern, Ireland).
- From these 3 regions, Flanders was defined by the highest density of the greenhouse locations in combination with a dense road network. This leads to a transport cost three times less expensive in relation to e.g. the region of Ireland (low greenhouse density and low road network density). However, the effect of the transport cost in the total cost is rather marginal (about 0.5%).



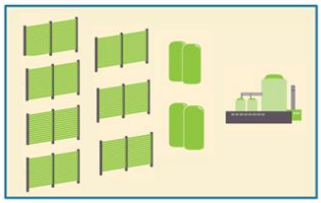
Map of greenhouse density (VITO)

Impact of decentral versus centralized organization of algae value chains?

- The question poses whether it would make a difference when a single algae grower and processor with high capacity (i.e. central approach) is replaced by several algae growers with low capacity (i.e. decentral approach) providing their biomass to a common algae processing plant.



Decentralized approach (milk model)



Centrilized approach

(Illustration: VITO)

- In terms of global cost, the impact is very limited. However, transport costs clearly vary between approaches and between regions. In most cases, the transport costs increase if a decentral design of the value chain is put into place. However, depending on the region's characteristics as well as the location of the centrifuge in some cases the central design is preferred. This highlights the importance of early-stage attention to the aspects of logistics and transport when sketching future value chain configurations since these decisions have a long-lasting impact on its overall performance.

More results to be found in the interactive IDEA dashboard: https://idea.vito.be/

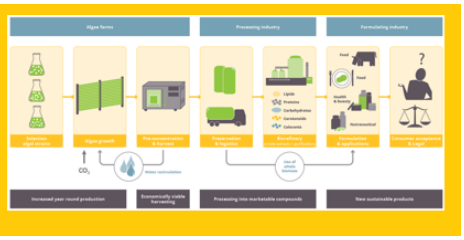
In conclusion: IDEA initiated an early-stage logistic assessment within algae value chains. The findings form a basis for further enrollment of the value chain. In next development stages of the value chain the impact of new insights can be assessed to support selection of the optimal location (cultivation, DSP) out of a set of specific candidate locations, to enable cooperation between cultivators, to organize logistics towards specific algae formulators, etc.

Interreg North-West Europe IDEA
European Regional Development Fund

IDEA - Implementation and development of economic viable algae-based value chains (NWE639)
Duration: 9/2017 – 10/2021, capitalisation till 12/2023
Website: www.nweurope.eu/IDEA

Lead partner: VITO, Belgium

Full IDEA partners:



Disclaimer: This document was drafted from the IDEA report T3.1.1. Report on the techno-economic and logistics assessment of the algae value. The report reflects 18 scenarios for the three aforementioned regions. For insight in the full context and adopted assumptions please consult the report at https://moov.vito.be/cases.