LCA of the REALM Microalgae Production System: Challenges of Methodology, Data, and Baselines

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Harmonising Algae-Based LCAs: Selecting Systems and Data Providers
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Scope of the project

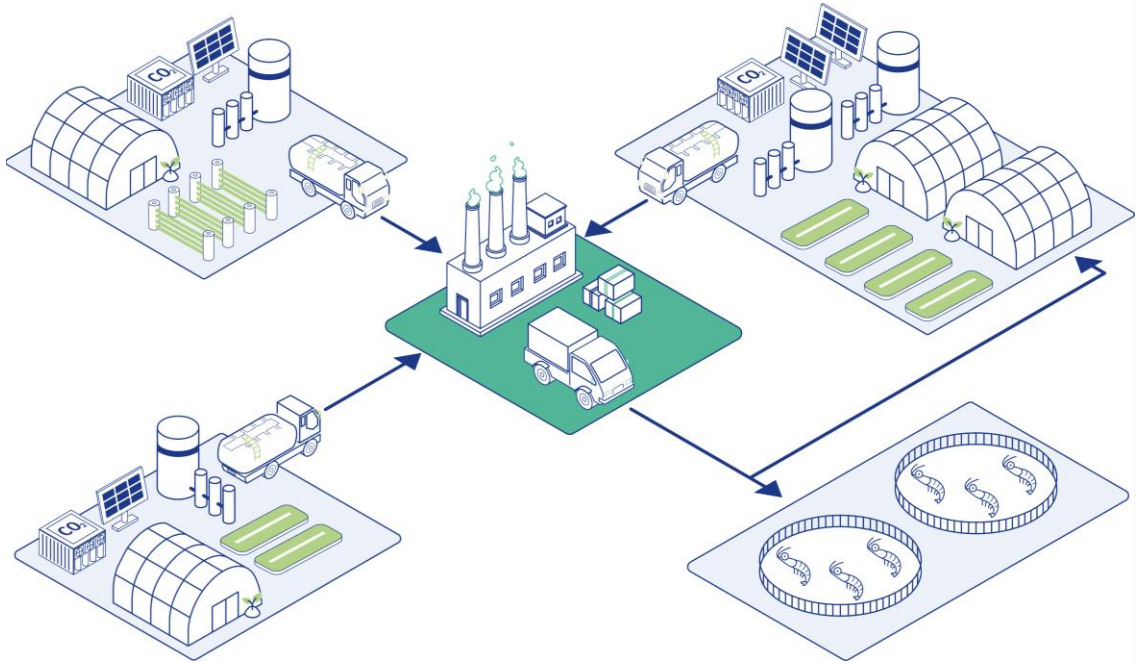
REALM

Scope

- Connecting microalgae production, agriculture, and aquaculture to create a low-cost and low-impact system
- Drainwater from agriculture is used for microalgae production, the algae is then used for the production of products for agriculture and aquaculture

Goals

- Develop a cost-effective water treatment system that combines food production and microalgae production
- Reduce microalgae production costs by utilising free nutrients from greenhouse drain water, capturing CO_2 from the air, and leveraging solar energy
- Create automated production systems with advanced sensors and predictive modelling to optimise microalgae growth rates while reducing labour costs
- Produce sustainable alternatives to current agricultural inputs and aquaculture feed products



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Scope of the project

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necton

Biorizon biotech

WAGENINGEN UNIVERSITY & RESEARCH

UNIVERSITY OF TURKU

GreenCoLab

UNIVERSITY OF TWENTE.

UCA Universidad de Cádiz

ESCI European Science Communication Institute

S²AQUA

UNIVERSIDAD DE ALMERÍA

imec

HUBEL Verde

OnePlanet Research Center

GRUPO LA CAÑA

phycoworks

DECERNA Delivering, unlocking, advancing the low-carbon economy

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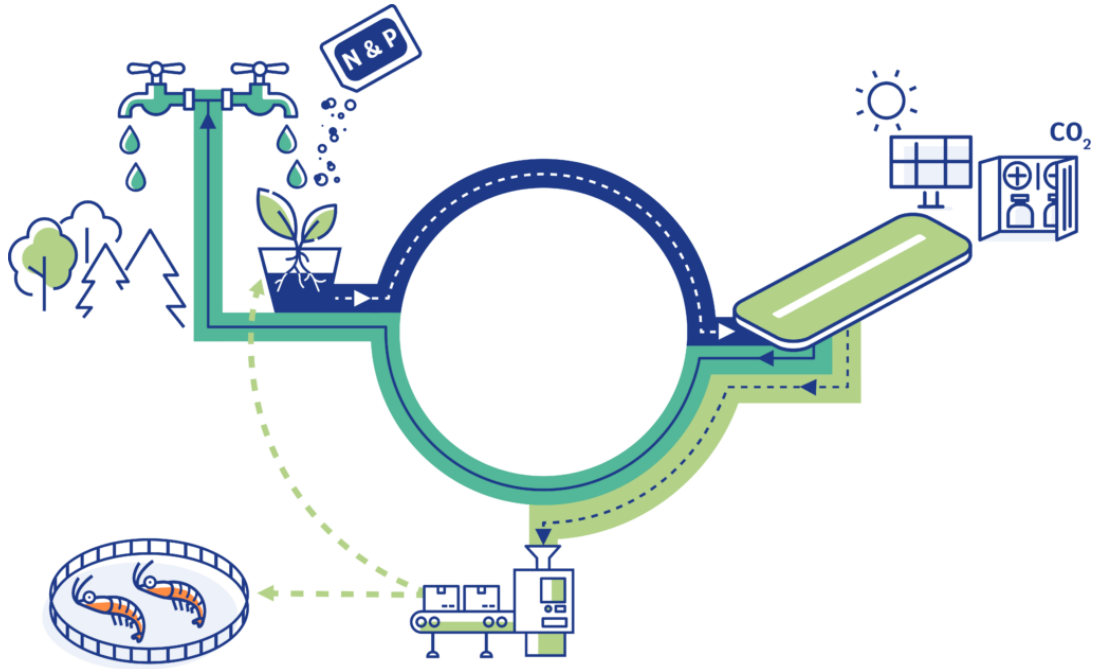
Value chain(s) analysed

Value Chain

Greenhouse Farmers → Microalgae Producers → Central Processing Facility → End Users (Farmers & Aquaculturists)

Production Process

- Greenhouse drain water collection (containing unused fertilisers)
- Transfer to microalgae cultivation systems (raceway ponds or photobioreactors)
- Solar-powered CO_2 capture from air for algae growth
- Continuous automated harvesting
- Transport to central processing facility
- Processing into final agricultural/aquaculture products



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Why is the LCA crucial for the project?

LCA is core to the project, as the focus is creating sustainable food and microalgae production systems. The following are vital outputs for the project;

1. Validates Project Claims
2. Identifies Optimisation Opportunities

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Methodology

- ISO 14040/44 compliant Life Cycle Assessment
- openLCA software platform – open source and allows collaboration between Decerna and GreenCoLab – multiple people in different countries can work on the same model
- Ecoinvent database (version 3.10) with "Allocation cut-off by classification“ and Agribalyse
- Integration with S-LCA using SOCA database
- Parameterised models to adapt for constant changes to design and processes
- Pedigree matrix assessments for uncertainty

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Methodology

Goal and Scope

Goal

Quantify environmental impacts of REALM's microalgae-based products

Scope includes

- Functional units: 1kg DW algae and 1kg final product
- System boundary: Cradle-to-gate
- Geography: Demonstration facilities in Portugal and Spain
- Time frame: 15-year operational lifetime
- Key processes: Water treatment, cultivation, harvesting, processing
- Impact categories: EF plus AR6 climate metrics

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Methodology

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Life Cycle Inventory

- Numerous site visits
- Energy monitors available for monitoring of large kit
- Constantly reviewing new data on designs
- Difficulty in that the project, as a research project, is constantly changing

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System and data providers

Primary Demonstration Facilities

- Necton (Portugal)
- Biorizon (Spain)
- System elements include: Greenhouses, Cultivation systems (raceways/photobioreactors), Harvesting assets (including centrifuge), Processing facilities, Water pre-treatment systems, Storage units.

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System and data providers

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Secondary Data

- Literature
- Previous work by Decerna (Magnificent, InteSusAl, etc.)
- Ecoinvent
- Agribalyse
- LCI data from other databases (not merging databases)

We have built up a large microaglae LCI library that we are organising. However, so has everyone else, and we need to stop this repetition across projects. We are all repeating the same research

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System and data providers

Baselines

- Deciding on baselines is difficult, and related to the experimental results of the projects to understand exactly what products we will compete with
- These baselines are generally commercial products where there are IP issues with acquiring the data
- Up-to-date versions do not exist within Ecoinvent, where data can be over a decade old
- We are reliant on literature research, patents, book chapters, and first principles

REALM Baselines

- Fertilisers (to compare with bioactive compounds + fertilisers)
- Macroalgae comparisons
- More TBD...

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System and data providers

Baselines for a range of previous microalgae projects Decerna has undertaken;

- Beta Glucans
- Fucoxanthin
- Phospholipids rich in EPA and DHA (from Antarctic tralwers)
- Walnut oil
- Biodiesel (palm oil-based)
- Fossil diesel
- Food products (protein-based estimations)

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System and data providers

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Why use this data?

- Primary data is always better but is just not possible
- Ecoinvent is popular but has significant holes and inaccuracies
- Agribalise fills in agricultural data
- Therefore, where possible, use other data gathered by Decerna

We need more collaboration to reduce repetition of work and incomparable models

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Results

- **Results:** Currently, all preliminary
- **Uncertainty:** Using pedigree matrices, especially good at removing old Ecoinvent data and finding issues in secondary data in general
- **Main Challenges:** This is a research project, so everything is changing constantly
- **How we will ensure the results will be available:** We will publish the results in the scientific literature and also (assuming no IP issues) possibly on a public Collaboration Server model

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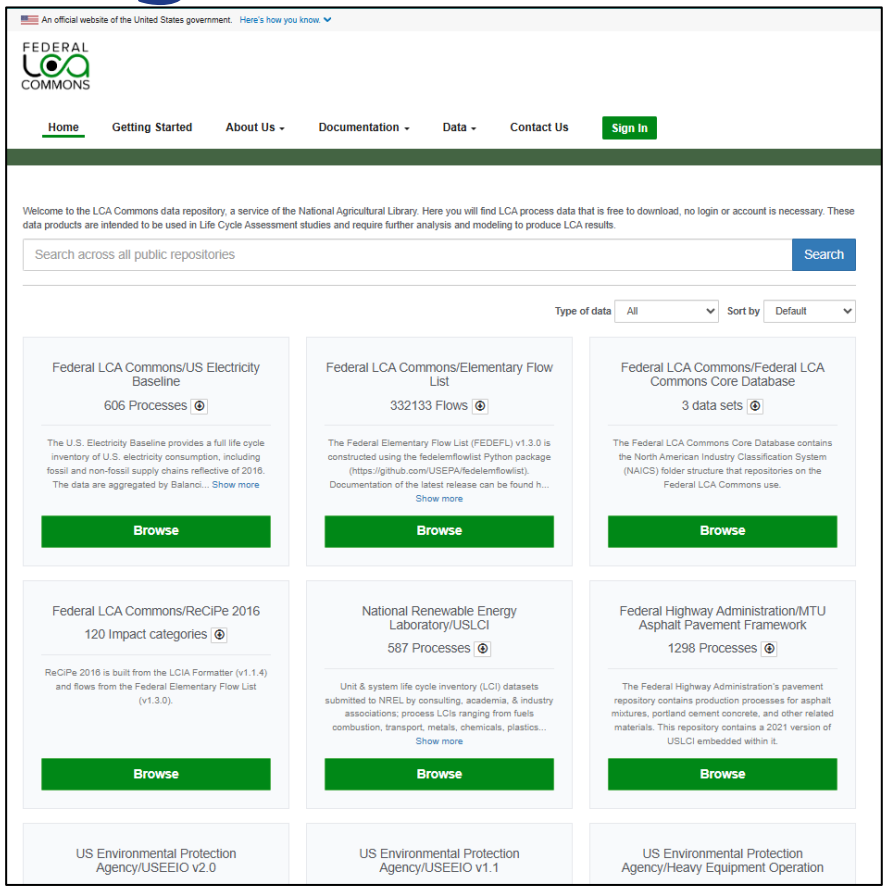
Conclusions & main messages

- We all rely on Ecoinvent; it‘s full of holes and approximations
- Research projects are particularly challenging as data constantly changes
- The ISO standards 14040 and 14044 allow too much freedom in general
- Everyone has their own selection of models of things not in Ecoinvent, and it would make sense to have a single LCI database that is open source, possibly following the LCA Commons model.



The US LCA Commons, a strong example of what we could do as a community to fix these issues.

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Thank you for your attention!

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Tom Bradley

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https://realmalgae.eu/

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