BIOETHANOL PRODUCTION FROM LONGLINE SEAWEED IN THE UNITED KINGDOM

Students: Ana-Maria Ionescu, Delphine Tavernier, Roumyana Kotopanova, Maxim Sverjinski, Gonzalo Valdés Dávila, Samuel Shannon
Supervisor: Dr Brenda Parker
Department: Biochemical Engineering

UCL

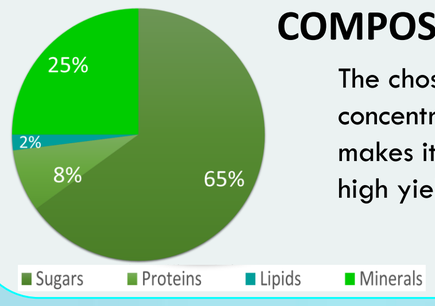
INTRODUCTION, AIM AND METHODOLOGY

Currently the EU's Renewable Energy Directive Plan is to ensure that 10% of all Europe's energy consumption by 2020 is from renewable sources. The production target of this project was to achieve 5% of the UK's road transport fuel demand, amounting to 600,000 tonnes of bioethanol.

The macroalgae *Laminaria Hyperborea* was chosen as a source of bioethanol due to its high sugar composition and ease to grow. Locating the production in Western Scotland is ideal, as it is situated far away from any wind farms, fishing routes and because of established research groups present in the area. The size of the site would be 4615 km^2 of coastline, and we would be using ropes for cultivation.

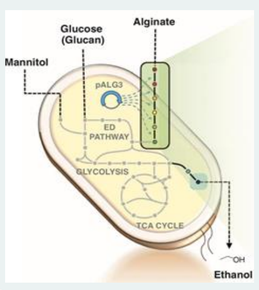
A cradle to gate process was designed, taking into consideration all steps starting from the seedling and growing of the seaweed to the final extraction of the ethanol. This will be the focus of our cradle to gate process.

LAMINARIA HYPERBOREA CHEMICAL COMPOSITION



The chosen seaweed has a high concentration of sugars 65%. This makes it suitable for production of high yield of bioethanol.

MODIFIED *E.COLI* BACTERIUM

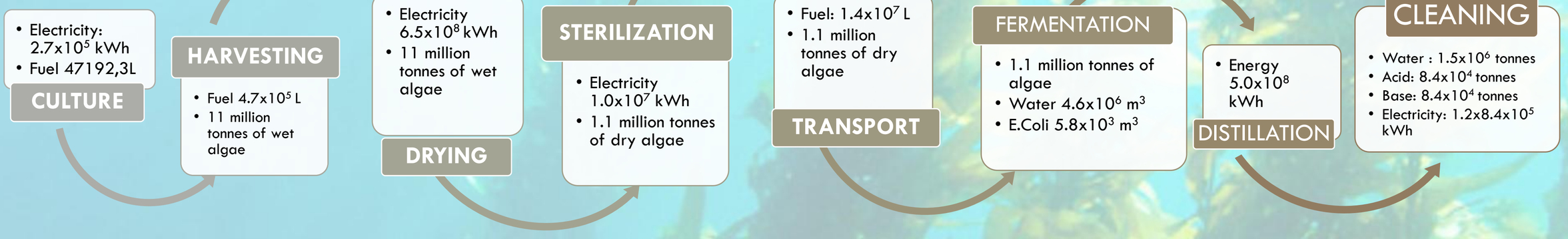


Modified E.coli is able to convert all sugar types present in algae into ethanol

2x more efficient than sugarcane conversion

Does not require chemical pretreatment since E.*coli* can carry simultaneous saccharification and fermentation

Capable of converting 80% of sugars in seaweed

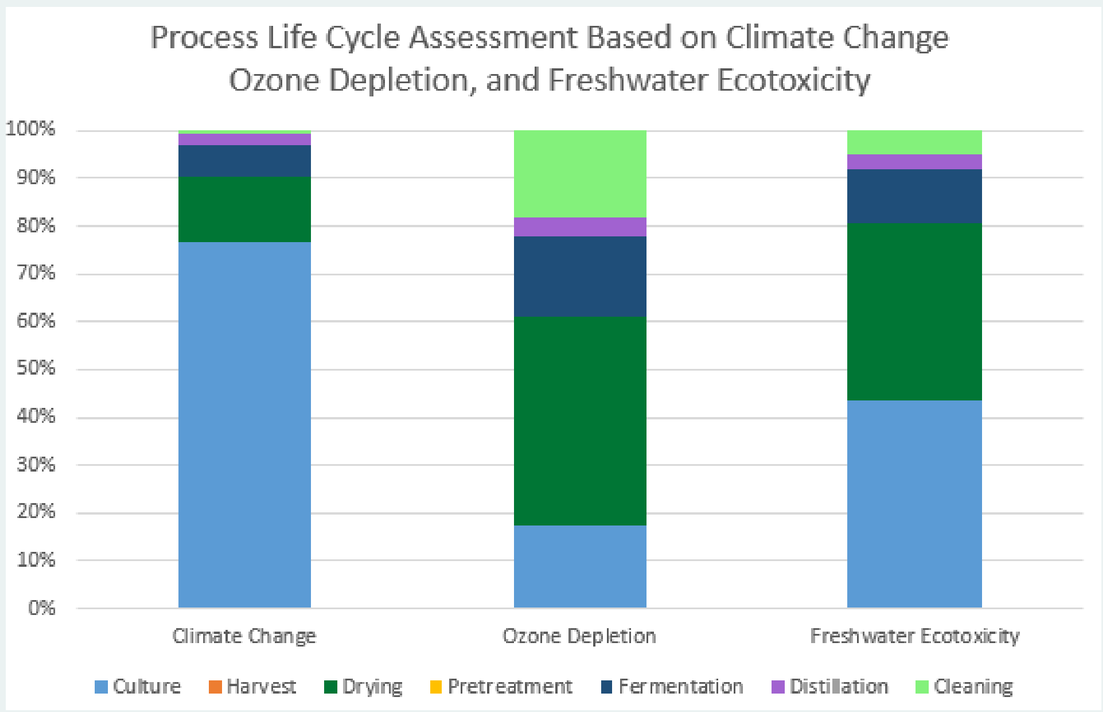


LCA ANALYSIS

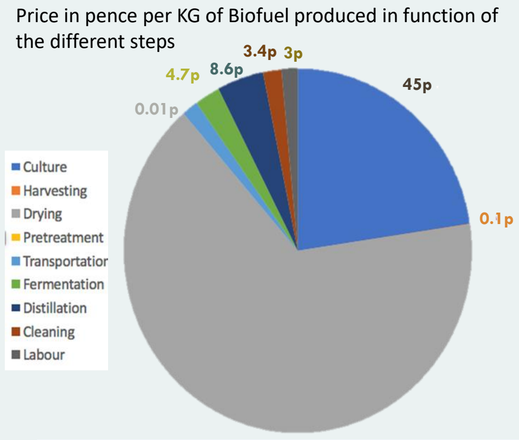
Climate Change:
- Most affected by culture step – 2.4x10^{10} kg of CO_2 emissions
- 52.3 kg of CO_2 emitted per kilogram of bioethanol produced
- EnAlgae Project (producing biofuel from macroalgae and microalgae) – 4.54 kg of CO_2
- Lower greenhouse gas emissions in EnAlgae project because of low culture amount – 5,000 kg of seaweed

Ozone Depletion:
- Most affected by drying (40%) and cleaning (17%) – usage of acid and base during cleaning and greenhouse gas emissions during drying
- Total ozone depletion of 8.5x10^{-7}kg CFC-11 per kilogram of bioethanol
- 1.1x10^{-7}kg CFC-11 in petrol production using wheat straw
- Need for ozone depletion reduction in future developments of the process

Freshwater Ecotoxicity:
- Affected mainly by drying and culture steps
- 0.1 kg 1,4-DB per kilogram of produced bioethanol
- 0.58 kg 1,4-DB in petrol production using wheat straw
- Similarity between amount of toxins release to freshwater – advantage to the new process



OPERATIONAL COSTS



The operational costs are mainly impacted by the Drying step as algae is made out of 90% water and thus the energy needed to get rid of it is quite significant.
The price of the biofuel was established at 1.99 pounds per kg.
If blended at 5% with petrol, the price would increase by 5%.

Price of conventional fuel (£)	Price of algae biofuel (£)	price of Fuel composed of 5% biofuel (£)	price increase (%)
0.95	1.99	1.00	5

PROSPECTIVE DEVELOPMENTS

Bioremediation – potential symbiotic relationship with a wastewater plant to reduce marine ecotoxicity and recycling of water is crucial
Facility relocation – reducing transportation and subsequent CO_2 emissions by basing a larger facility near the feedstock instead of the 3 currently available processing plants.
Directed Evolution – 2018 Nobel prize in Chemistry; could help improve the single step microbe's functionality leading to improved process efficiency and yields.

→**decrease the cost and increase the profit**

CONCLUSION

The current 2 facilities available were not enough to meet the 5% fuel demand targets and could only facilitate 3.3% at a competitive price of £1.99/litre. To attain the requirement, we propose a single larger facility located in Scotland, as this would also reduce transport and operational costs of the bioethanol plant. Certain process efficiencies could be improved such as the seaweed harvested per hectare, which has been suggested to be higher. Overall, this production method has great potential and could lead the UK to being a large bioethanol manufacturer in Europe.

REFERENCES
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