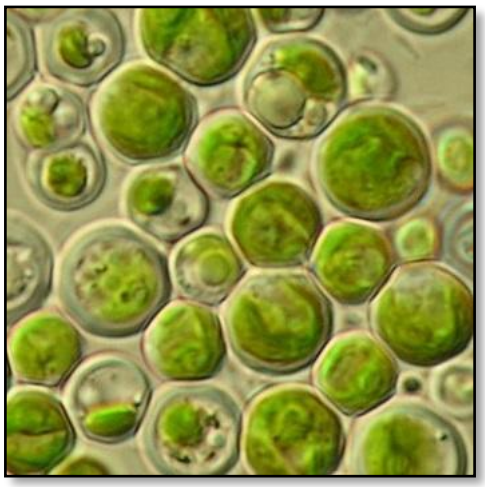
Altered Carbon

Concept: Algae Production for CO_2 Sequestration

The Equation for Photosynthesis:

$$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2 \qquad \Delta H^0 = +2870\ \frac{kJ}{mol}$$



Chlorella Vulgaris

Why use microalgae for CO_2 sequestration:

- On average, 2 to 3 pounds of CO_2 utilized for each pound of algae grown
- Algae populations can grow exponentially, with mass doubling up to every 24 hours
- Relatively low infrastructure requirements to grow
- Numerous uses for algae produced
- Extraordinarily energy-rich crop, exceeding the energy value of soy by 30-fold

Possible Revenue Streams (Subsidises Cost of Sequestration):

- Sale of Carbon Credits
- Disposal of CO_2 for industry
- Algae use:
- Food source (people)
- Livestock feed
- Bioplastics
- Fertilizers
- Renewable chemicals
- Biodegradable packaging

Information on Growing:

- Maximal cell density in culture is limited due to extinction of light by the algae themselves
- Besides CO_2 and light, algae requires nutrients to grow, nitrogen (N) and phosphorus (P) being the most important. This can be supplied in the form of agriculture fertilizer.
  - Up to 5% of the mass of algae comes from nitrogen and 1% from phosphorus
- Microalgae concentrations in water range from 0.02 to 0.05 percent dry mass/water in raceways and 0.1 to 0.5 percent in tubular reactors (meaning 1 tonne dry biomass can be recovered from 200 – 5000 m^3 water).

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Industrial Production of Algae for CO_2 Sequestration

In order to scale to achieve goals, the production of algae has to be a continuous system that ensures algae remains in the exponential growth phase.

There are two main types of algae cultivation, closed bioreactors and ponds/raceways. Bioreactors are typically more efficient at mass production but suffers in scalability. A linear raceway design seems to offer the best tradeoffs between scalability and mass production.

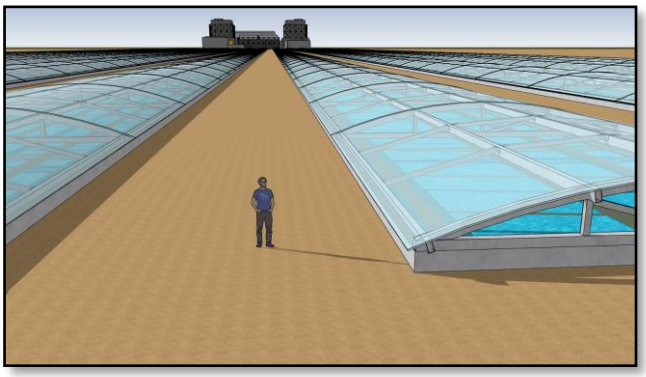
The design below consists of a linear pond, 1m in depth, 15m wide and 1200m long. This could be built as simple as a trench with a liner. Based on middle of the road assumptions, each linear raceway could be capable of:

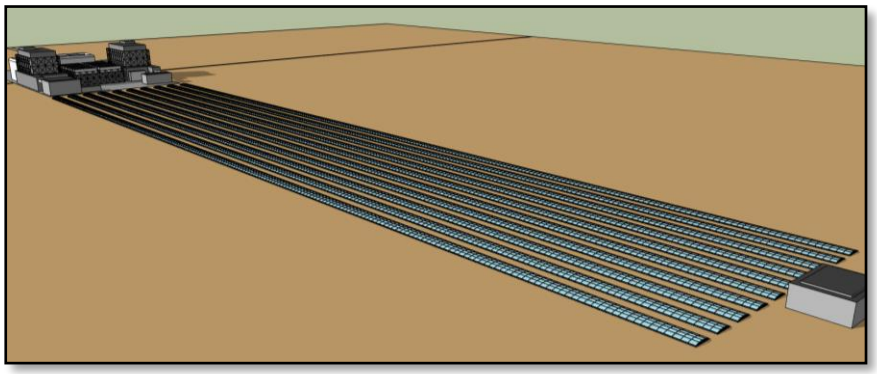
- Sequestering 13,000 tonnes of CO_2 annually
- Producing 6,500 tonnes algae annually

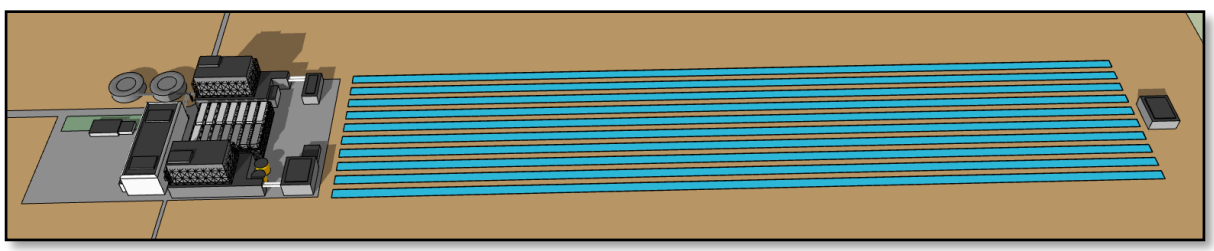
Many of the assumptions used will need to be validated experimentally.

Raceway Ponds

Enclosed Bioreactor







Concept Algae CO_2 Sequestration Plant (131,000 tonnes CO_2 / 65,000 tonnes algae annually)