FOOD FROM ELECTRICITY AND CO_2

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www.neocarbonfood.fi

A joint research between Lappeenranta University of Technology (LUT) and VTT-Technical research centre of Finland

Background

- Rapid population growth and continuously improving the standard of living leads to higher demand of protein (mainly meat and fish) especially in the developing countries
- The food safety can be endangered by the over fishing and the lack of arable land, fertilizers, and fresh water

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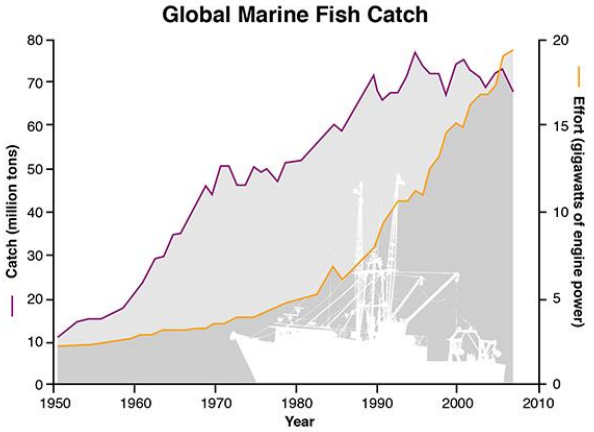
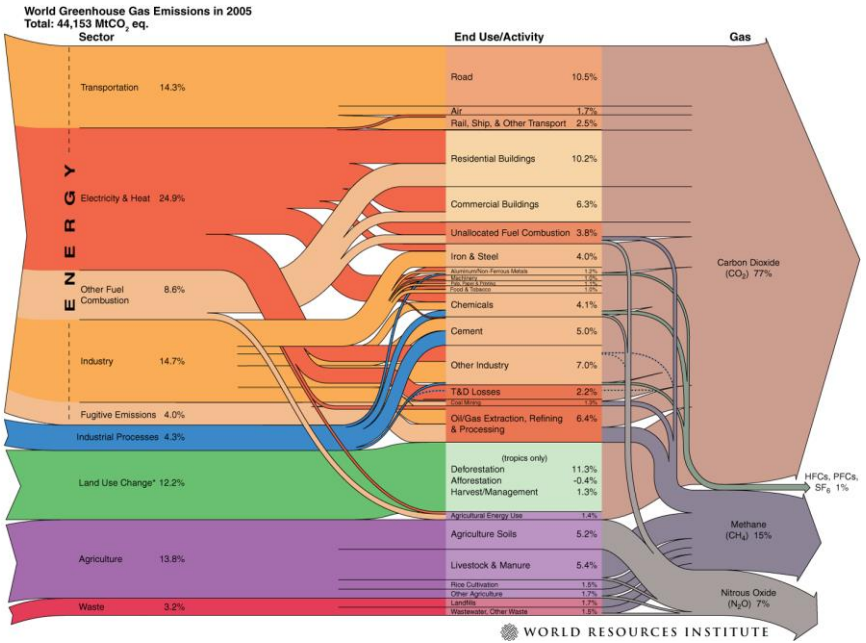


http://www.reefresilience.org/coral-reef-fisheries-module/coral-reef-fisheries/overfishing/

Effect of food production on climate change

- Agriculture (including land use change) is responsible for a quarter of the global GHG emissions



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Principle of bioreactor with in situ electrolysis

- Microbial protein production with gas fermentation is known for decades, but has so far not been able to challenge the traditional farming
- The hydrogen is the source of energy and CO_2 can be from any source

Electricity

CO_2

Water

Minerals

Microorganisms

Food & Feed

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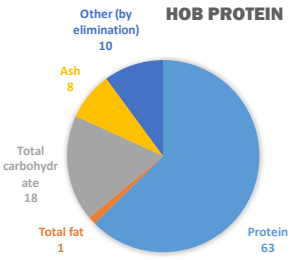
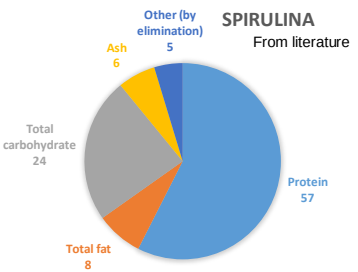
https://www.youtube.com/watch?v=b71CBoa1Fas

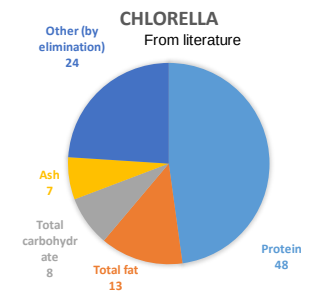
End product

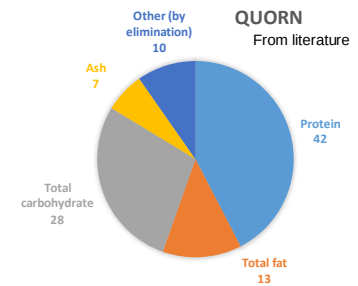
- MP-based products in market: Spirulina, Quorn, FeedKind®, UniProtein®

- MP produced using electricity has similar biomass composition as MP produced using direct sunlight or sugars.









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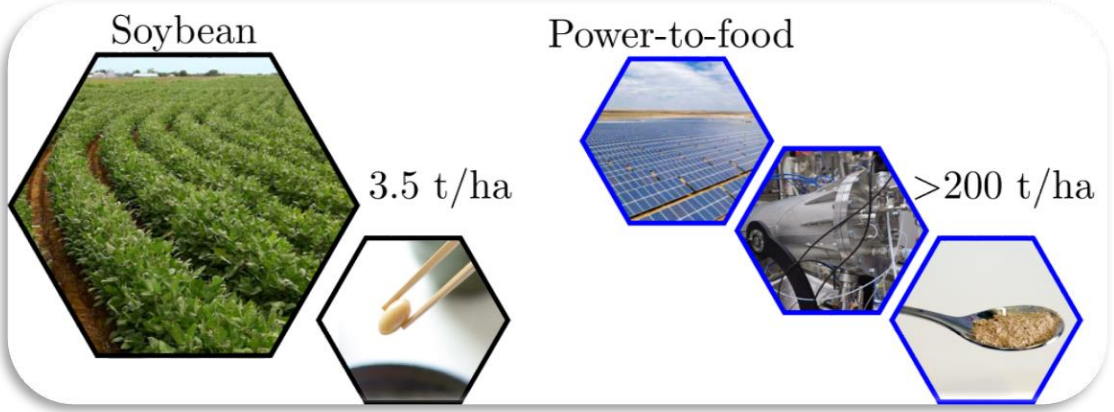
Production rate

- The production rate of MP is far higher compared with photosynthesis based production



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Life cycle assessment (LCA)

	Global warming potential [$kg_{CO2\text{-}eq}/kg_{protein}$]	Land use [$m^2/a*kg_{protein}$]
PtF wind energy	0.89	0.042
PtF solar energy	1.27	0.054
Feedkind	2.23[a)]	0.1[a)]
Quorn	16.55[b)]	2.76[b)]
Soybean	2.025[c)]	4.94[d)]
Pork	20-55[f)]	40-75[f)]

a (Cumberlege et al. 2016),b(Head et al. 2011),c(da Silva et al. 2013),d(Mekonnen and Hoekstra 2012),e(Jekeyinfa 2013), f(Mekonnen et al. 2012)

- PtF process itself consumes only small amount of water

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Research questions

- The most suitable micro organism
- The optimal cultivation media
- Current density limitations
- The effect of electrode materials on the energy efficiency
- The effect of electrode geometry on the energy efficiency
- Process control aspects
- Direct air capture of CO_2

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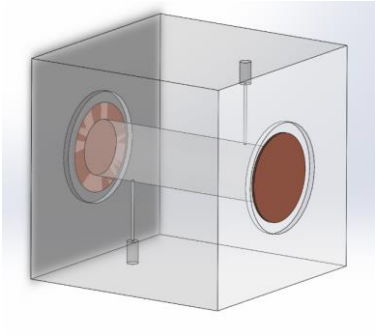
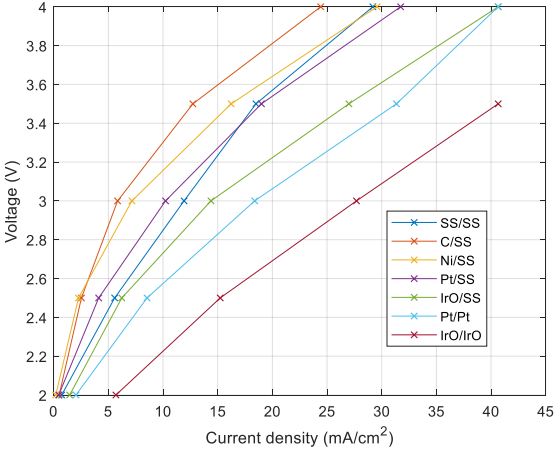
Electrode material tests

- Cyclic voltammetry is applied to define the cell voltage as a function of current density
- Low electrolyte conductivity ~1 S/m, pH neutral
- Hydrogen production estimated based on current
- Voltage efficiency analyzed as a function of current density
- Various electrode material combinations studied





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Pilot plant

- Pilot plant will be implemented in June 2019 at LUT
  - CO2 direct air capture & solar electricity
  - MP growth with in situ electrolysis is demonstrated
  - Electricity-to-biomass efficiency is analyzed
  - Continuous process control
  - Post-processing of biomass is not included
- Targets
  - Reactor volume 20 L
  - Productivity 10 g h^{-1}
  - Energy consumption 10 kWh kg^{-1}
  - Electricity-to-biomass efficiency 60%

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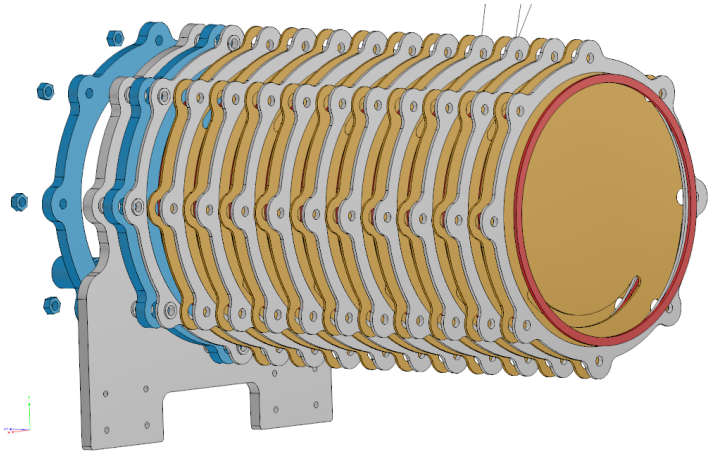
Electrolyzer stack for in situ electrolysis

- Stack structure maximizes the active electrode area
  - Single electrode area ~380 cm^2
  - 10 cells in series
  - Stainless steel electrodes with catalyst coating



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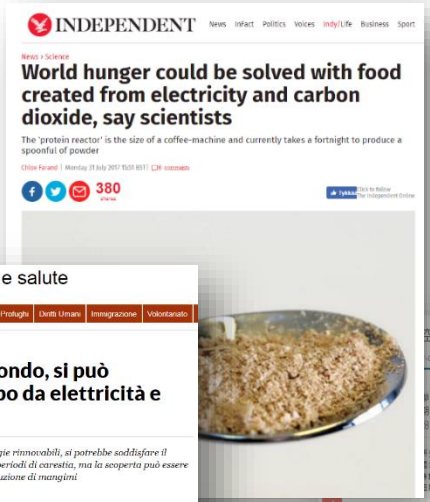
Mentions in international media



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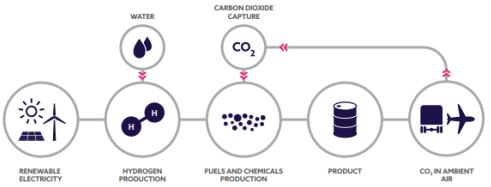
Power-to-X projects at LUT

NEO CARBON ENERGY

TRUST IN RENEWABLE.

A WORLD ELECTRIFIED BY SOLAR AND WIND



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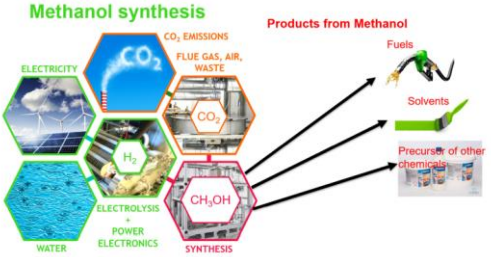
Power-to-Methanol Energy Efficiently

/ SIMULATION BRINGS A GLOBAL 100% RENEWABLE ELECTRICITY SYSTEM ALIVE FOR THE FIRST TIME



Explore online: www.neocarbonenergy.fi/internetofenergy/

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Thank you!

- Spin-off company from the projects in 2017: Solar Foods Ltd (www.solarfoods.fi)

- Related projects:
  - Microbial Oil and Proteins from Air by Electricity-Driven Microbes (Academy of Finland)
  - Feed and Food from CO_2 and Electricity-Research and Piloting of Future Protein (Technology Industries of Finland Centennial Foundation, Jane and Aatos Erkko Foundation)
  - Smart Energy Transition (Academy of Finland)

Effect of current quality on the water electrolysis energy efficiency

- Thyristors converters enable high currents, but excite significant current harmonics
- Stack specific energy consumption was increased by 1% at full load and by 10% at partial load because of the 12-pulse thyristor bridge harmonics

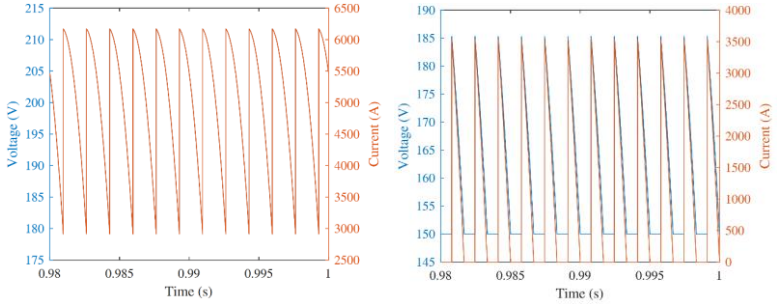

Fig: 12-pulse thyristor bridge voltage and current waveforms at 5000A and 1000A

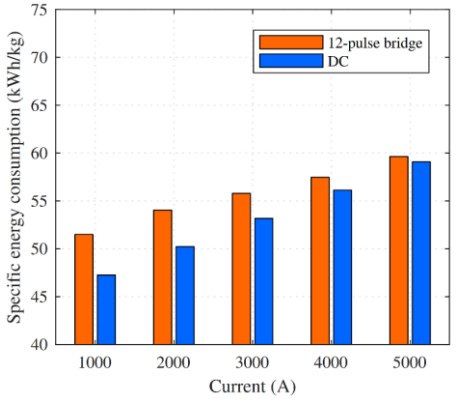

Fig: 12-pulse thyristor bridge specific energy consumption compared with pure DC

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