NEO-CARBON FOOD

PRODUCING PROTEIN FROM ELECTRICITY

Dr. Juha-Pekka Pitkänen, VTT Technical Research Centre of Finland
Prof. Jero Ahola, LUT Lappeenranta University of Technology
Dr. Pasi Vainikka, VTT Technical Research Centre of Finland
Dr. Vesa Ruuskanen, LUT Lappeenranta University of Technology
Leo Ojala, VTT Technical Research Centre of Finland

Espoo, January 30th 2018

NEO CARBON FOOD





NEO CARBON FOOD

Why Neo-Carbon Food

1. One fifth of human caused greenhouse gas emissions is connected to food production.
2. World population 7.5 → 9 billion by 2050.
3. Climate change and draughts reduce food yields. Global over fishing: peak annual catch in 1996.

Minimal requirements for protein production

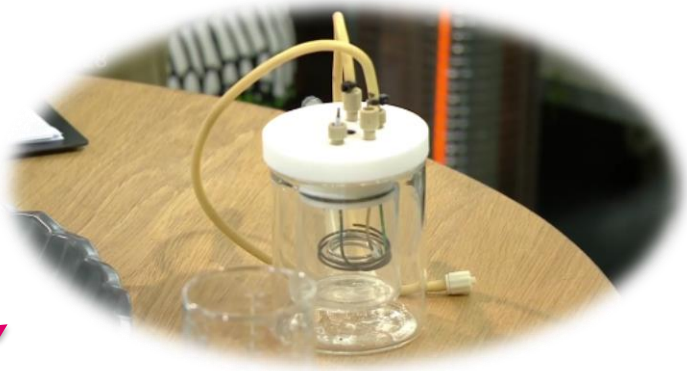
Electricity

CO_2

Water

Minerals

Microorganisms





Food & Feed

Protein produced with microorganisms is called single-cell protein; SCP.

”Algae” Spirulina and *Chlorella* are produced using direct sunlight.

NEO CARBON FOOD

Mycoprotein Quorn is produced from sugar using a *Fusarium* fungus. Produced in closed bioreactors.

Minimal requirements for protein production

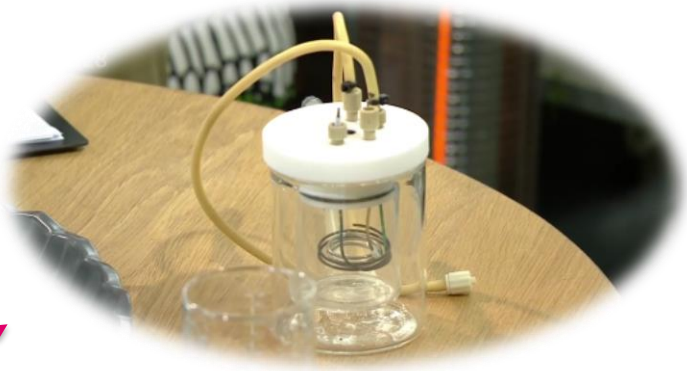
Electricity

CO_2

Water

Minerals

Microorganisms





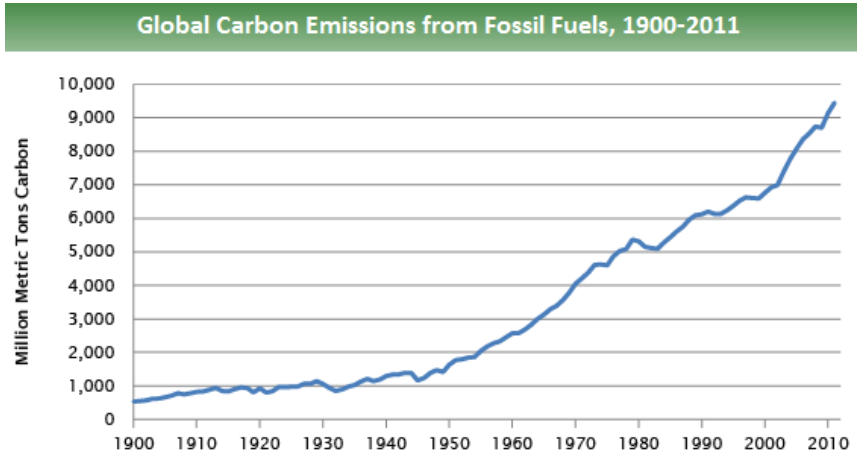
Food & Feed

First publications about growing microbes with CO_2 and electricity from the 1960s by Prof. Hans Günter Schlegel and his colleagues (Nature 1965).

NEO CARBON FOOD

Russian Academician Georgy A. Zavarzin and his colleagues also studied similar approaches for instance related to space explorations.

Electrification can help to combat the two biggest global challenges



Boden, T.A., Marland, G., and Andres R.J. (2015). Global, Regional, and National Fossil-Fuel CO_2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy.

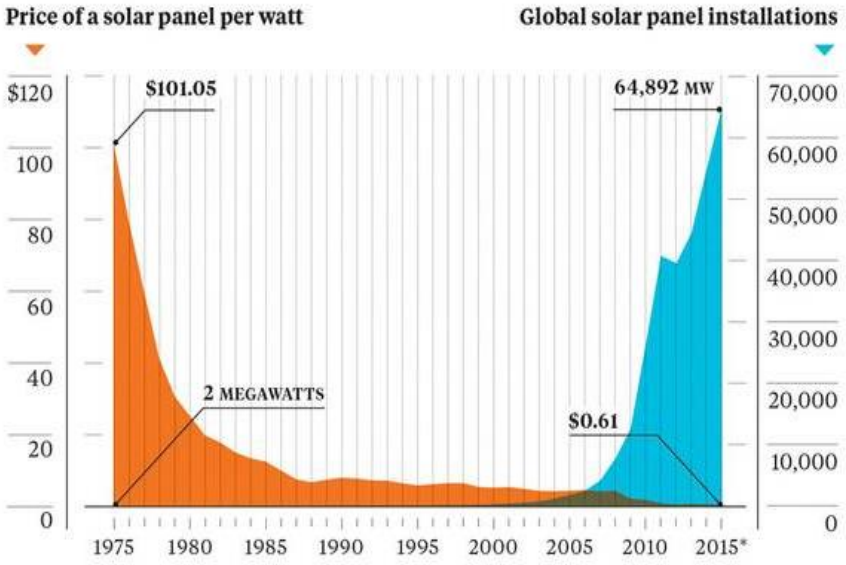
CO_2

NEO CARBON FOOD

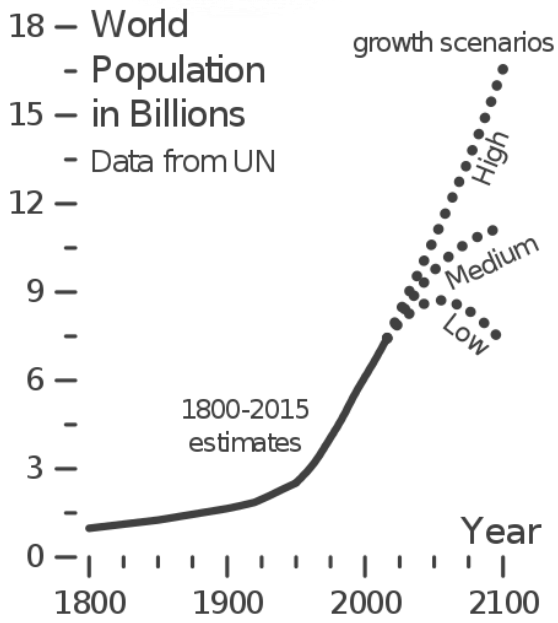
Food



Solar power

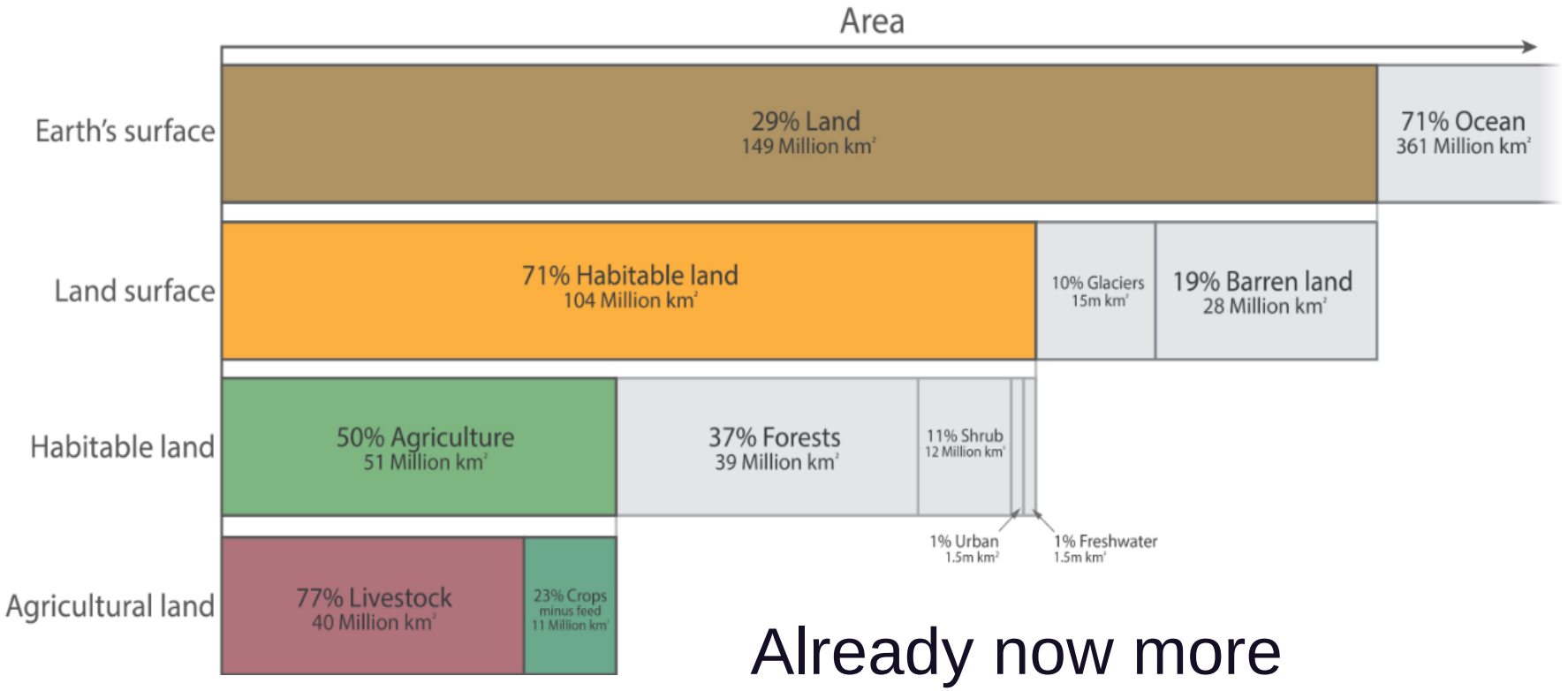


Graphic Treehugger.com; data from Earth Policy Institute



By Bdm25 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=51036438

We need to use land area efficiently

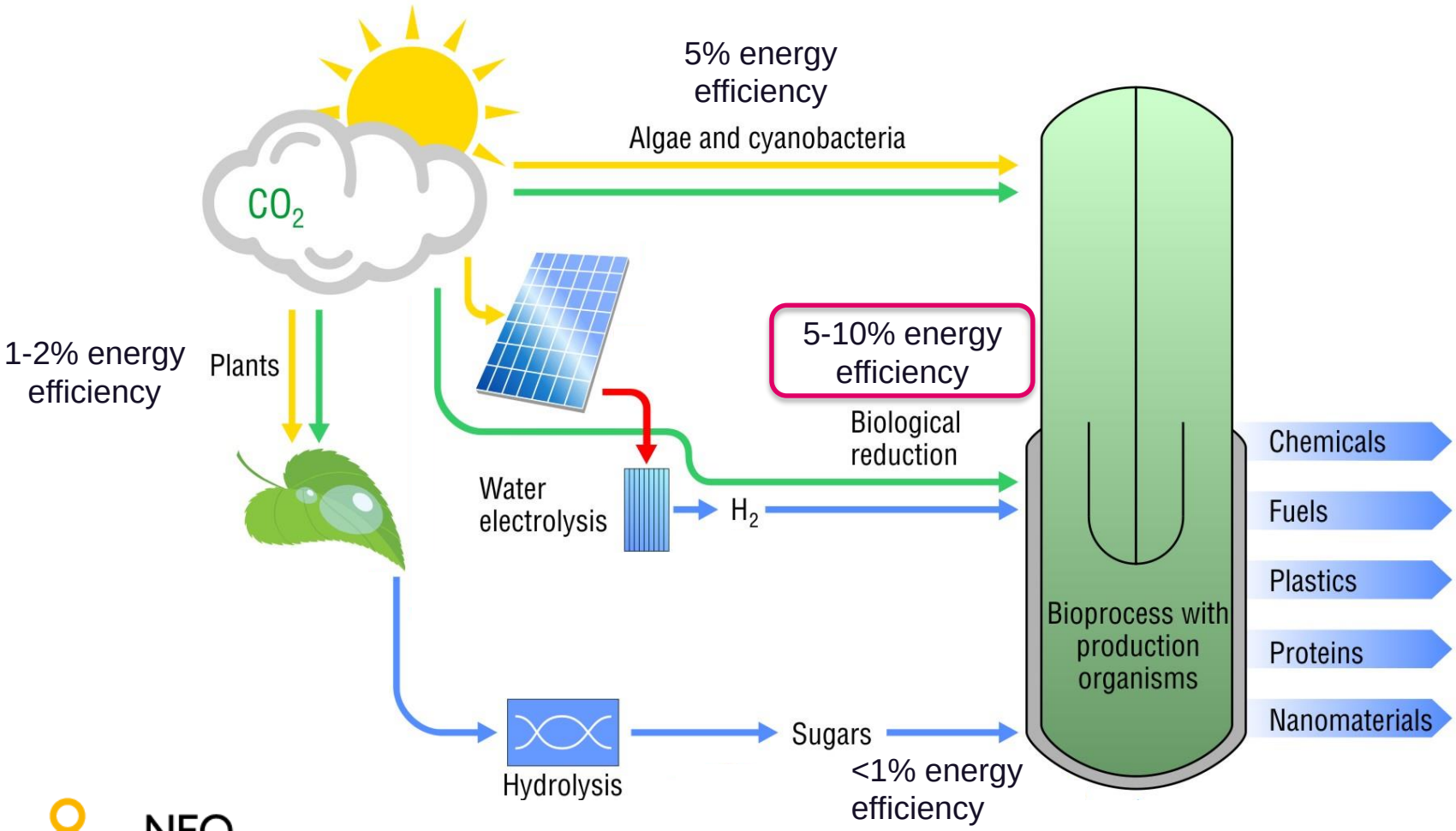


Already now more habitable land used in agriculture than in forests

NEO CARBON FOOD

Max Roser and Hannah Ritchie (2017) – 'Yields and Land Use in Agriculture'. Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/yields-and-land-use-in-agriculture/

Maximal efficiency from sunlight



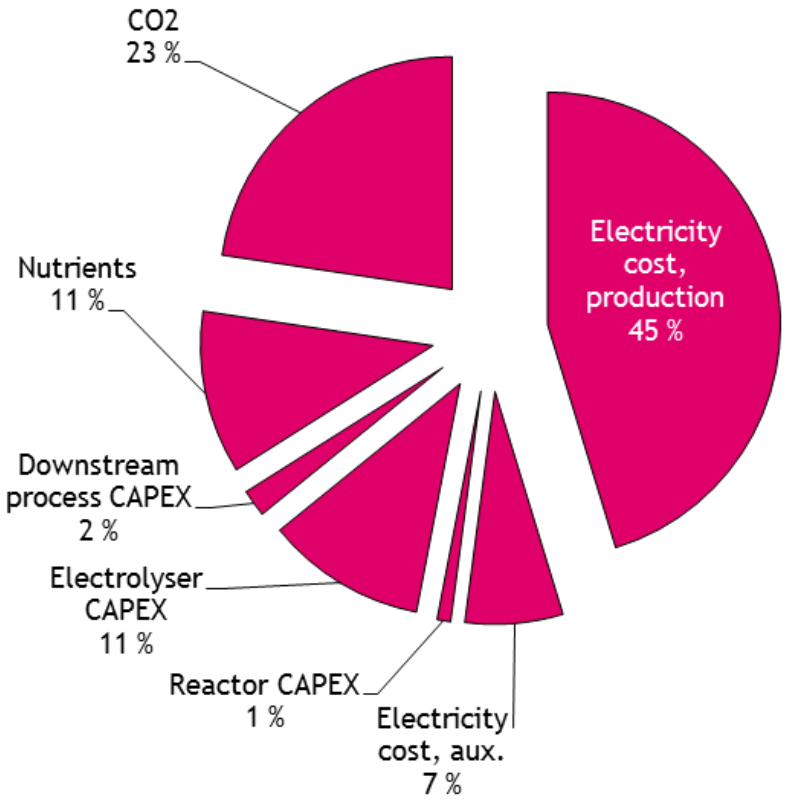
NEO CARBON FOOD

Calculations by Peter Blomberg, VTT

How much would it cost when ready?

Electricity 40 €/MWh, CO_2 100 €/t → Protein c. 2 €/kg

Cost estimation is based on bioprocess facility producing 1 million kg/a protein at 60% electricity-to-biomass efficiency.



NEO CARBON FOOD

- Global trade soy protein 1 €/kg
- Protein food additive 3-10 €/kg in wholesale
- Quorn 6 €/kg UK retail price; c. 60 €/kg of protein

Aim for food product – what is the market potential

Competitors:

- Quorn
- Tofu
- Insects



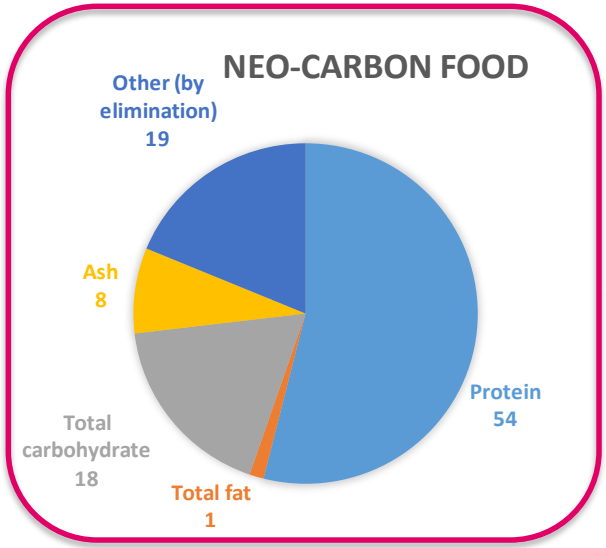
Meat Substitutes Market worth 5.96 Billion USD by 2022 at a CAGR of 6.6% from 2016

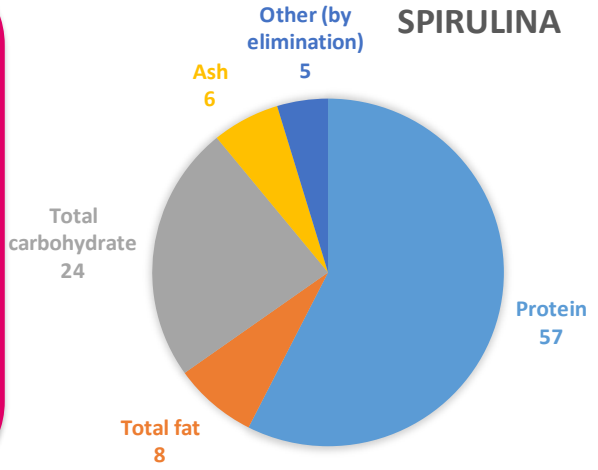
Marlow Foods is the producer of Quorn.
Their 2015 annual results:

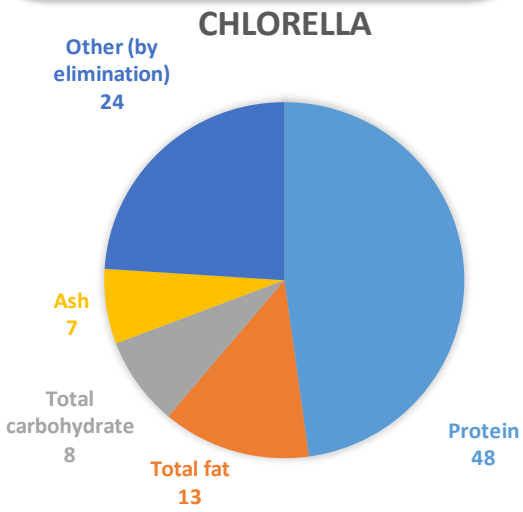
- Turnover GBP 158.1M
- Sales growth 5.2%
- Gross profit GBP 65.6M

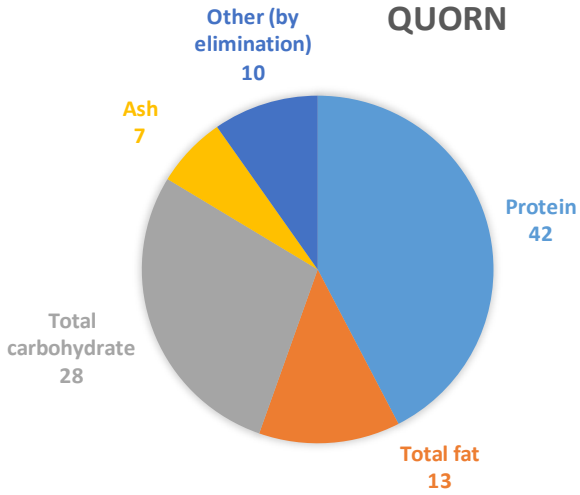
NEO CARBON FOOD

Biomass composition is good



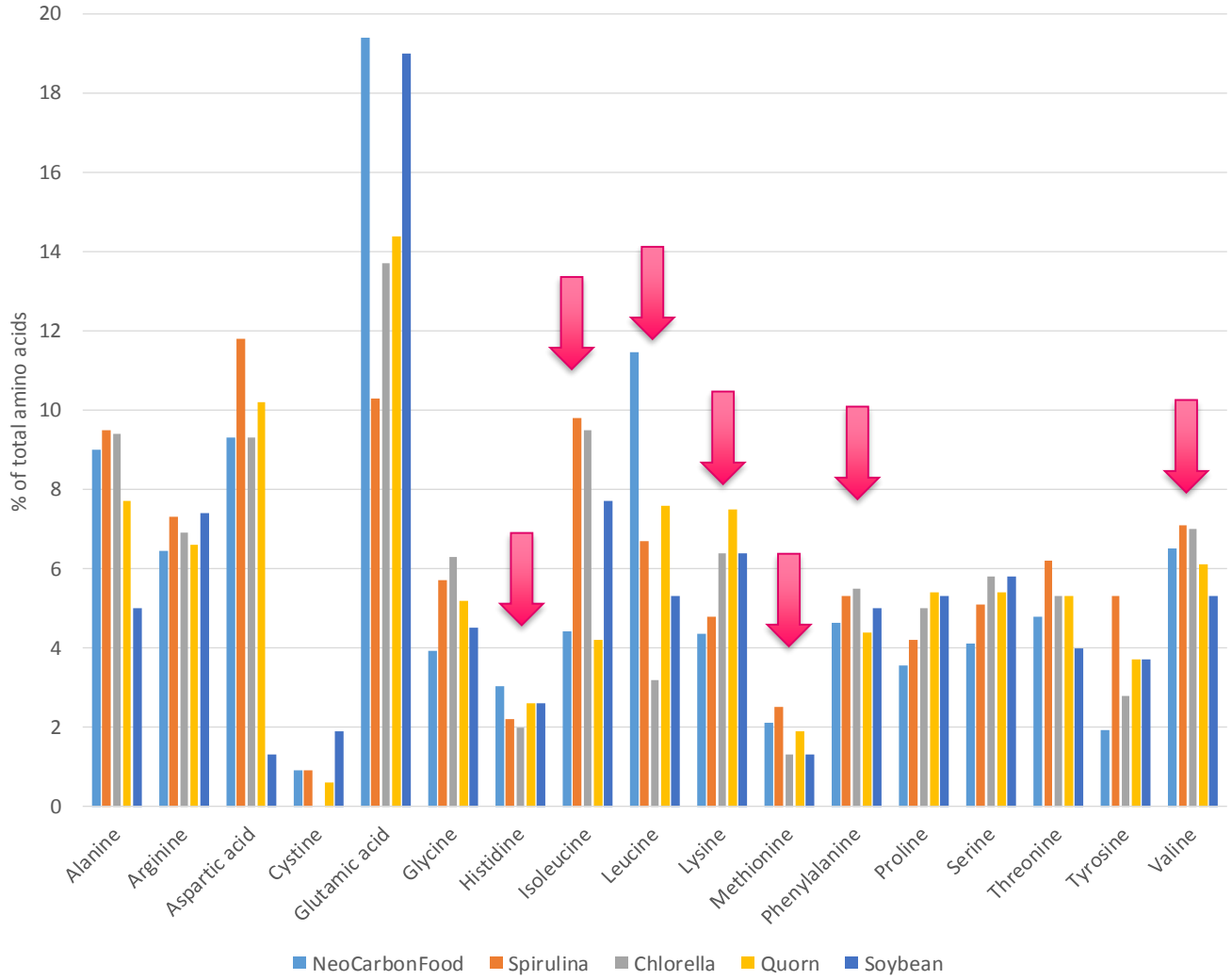






NEO CARBON FOOD

Amino acid composition is good



NEO CARBON FOOD

Indicative development roadmap

Academy of Finland project

Piloting project TT100

Novel food testing

Start of production

2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

TRL 3
100 mL

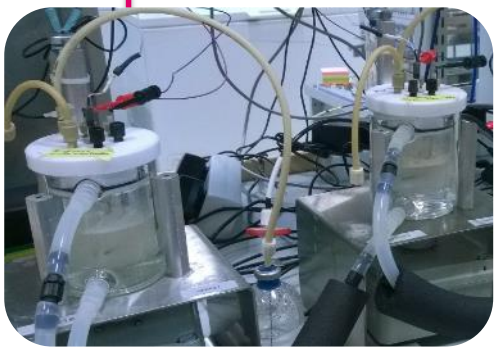
TRL 4
5 L
0.01 kg/d

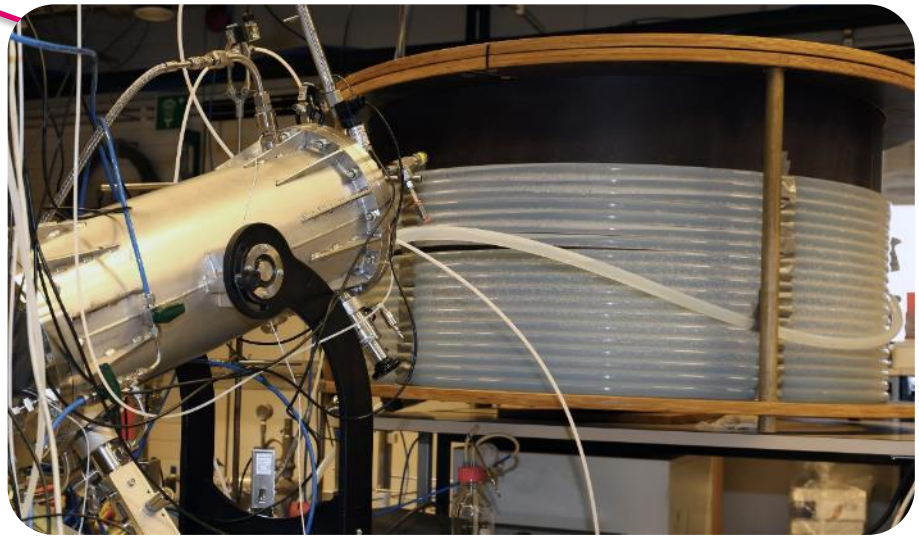
TRL 6
2000 L
10 kg/d

TRL 7
20,000 L
550 kg/d

Construction of the production facility

TRL 9
200,000 L
5500 kg/d





NEO CARBON FOOD

Benefits of protein from electricity

- Separation from direct land-use of agriculture = can be installed anywhere
- Efficient route for protein from sunlight = uses smaller land area than plants
- Aim for food product using electricity and CO_2 as the main inputs



Growth season 12 months!

E.g. converting CO_2 from 3rd smallest pulp mill in Finland to 59 million kg of protein per year = over half of Finland's protein deficit using 1% of Finnish electric power generation



NEO CARBON FOOD

Acknowledgements

Collaborators

- LUT: Jero Ahola, Vesa Ruuskanen, Jani Sillman, Georgy Givirovskiy
- VTT: Pasi Vainikka, Cyril Bajamundi, Jere Elfving

Coworkers

- Mikko Wuokko; MSc student on CO_2 + electricity cultivations
- Leo Ojala; PhD student in MOPED project, cultivations and calculations
- Anu Tamminen; cultivations and ”running the shop”
- Peter Blomberg; calculations
- Atte Mikkelson, Heli Nygren, A-L Ruskeepää, Tuulikki Seppänen-Laakso, Riitta Alander, Marita Ikonen, Päivi Matikainen, Ulla Vornamo, Tuuli Teikari, Airi Hyrkäs; analytics