The 2nd International Resource Recovery Conference

Pilot scale production of single cell proteins using the power-to-protein concept

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Introduction

Future global challenges

- **Population increase:**

  9 billion people in 2050

- **Increased protein requirement:**

  From 473 in 2014 to 943 MT protein in 2054

- **Environmental concerns:**

  Sustainability was a "nice to have"; now it is a priority

- **Climate change:**

  Extreme weather including droughts will undermine future food production potential

Introduction

Proteins from micro-organisms

Alternative protein sources are currently subject of intensive research

single cell protein (SCP) is receiving renewed interest

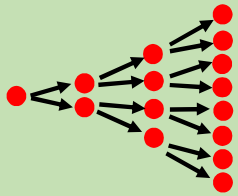
We give it a new name:

Microbial Protein = PROMIC

INPUT

- **Microorganisms:** Yeast, algae, bacteria
- **Energy source:** (Org-C, H_2, CH_4)
- **Carbon source:** (Org-C or CO_2)
- **Minerals:** (N, P, K…)
- **Aeration:** (Air or O_2)

AEROBIC FERMENTATION



Fast growing microorganisms (doubling times of 2-6 h)

DOWNSTREAM PROCESSING

Harvesting

Drying

High quality protein source suitable as feed or food supplement

SOURCE: MATASSA, S. ET AL., ENVIRON. SCI. TECHNOL., 49 (2015), 5247 - 5254

Power-to-protein concept

Biochemical conversion with carbon capture and ammonia recovery

power to PROTEIN

"*Can direct conversion of used nitrogen to new feed and protein help feed the world*?"

Ammonia from the waste water

Hydrogen Oxidizing Bacteria (HOB):

Aerobic, facultative autotrophic bacteria
By means of H_2 oxidation, CO_2 and NH_3-N
are incorporated into **protein-rich biomass: SCP**

$$5.2\ \mathbf{H_2} + 1.5\ O_2 + 1.0\ \mathbf{CO_2} + 0.2\ \mathbf{NH_3} \rightarrow \mathbf{CH_{1.7}O_{0.5}N_{0.2}} + 4.6\ H_2O$$

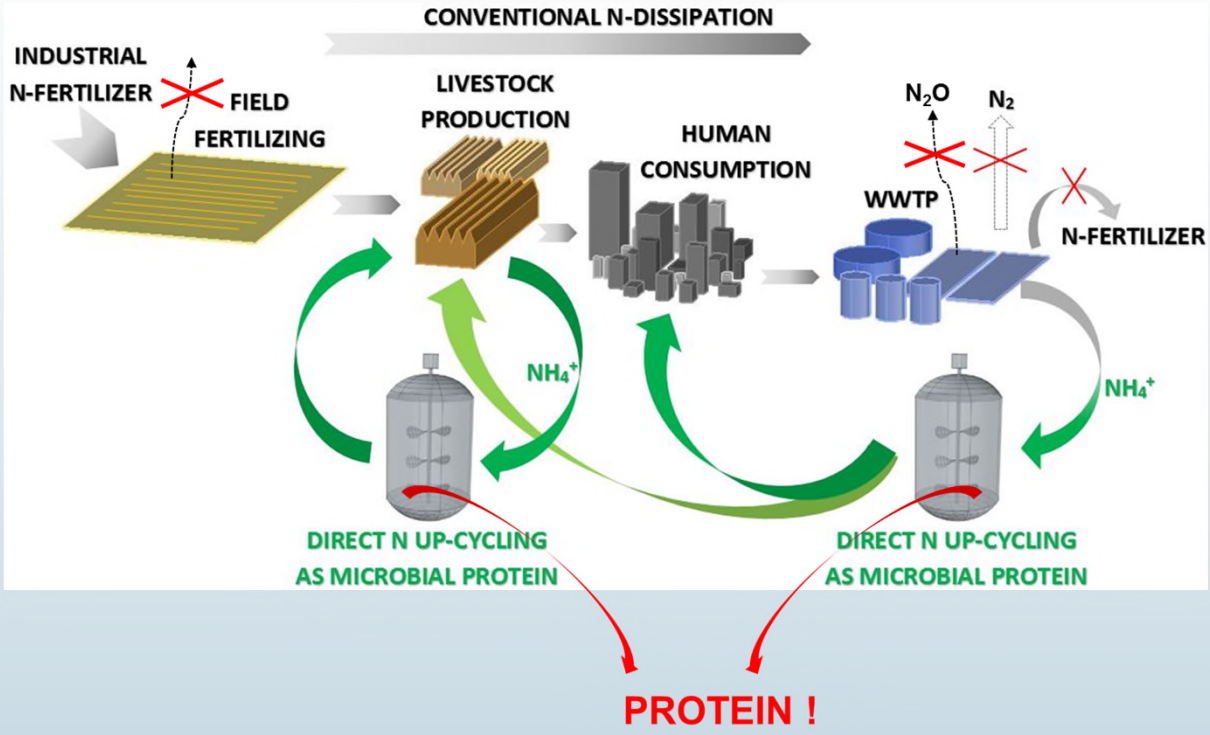
Power-to-protein concept

Direct upcycling of ammonia as microbial protein

The man-made artificial nitrogen cycle is very inefficient

Haber Bosch → reactive N:
145 million tons/year enter our biosphere

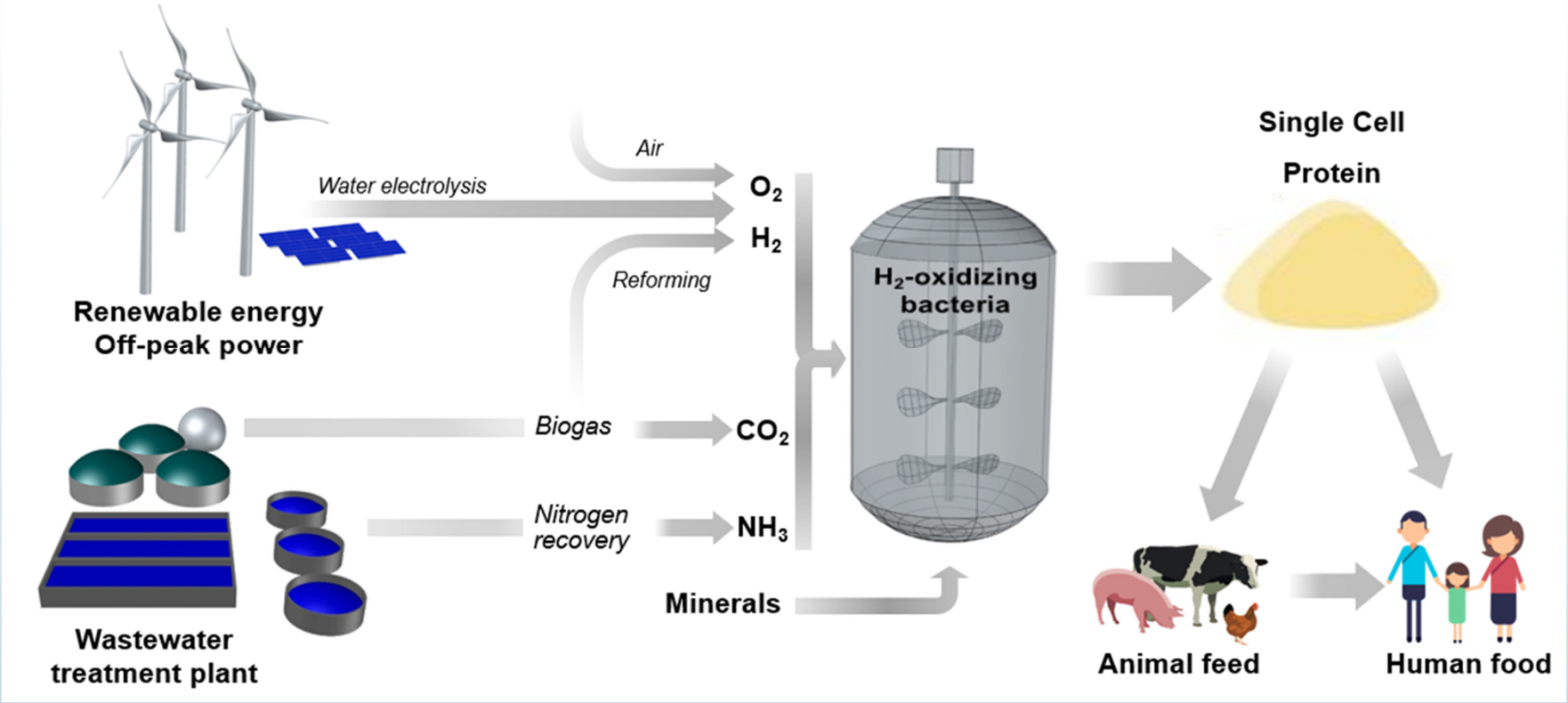
Only 16% becomes edible protein; 84 % is lost to the environment



SOURCE: MATASSA, S. ET AL., ENVIRON. SCI. TECHNOL., 49 (2015), 5247 - 5254

Power-to-protein concept

All sources from the waste water chain



Power-to-protein lab set-up

Laboratory set up and results at Avecom Gent

LAB FACILITY AVECOM

CSTR; 5 liter reactor

Batch mode

Enriched mixed culture

H_2 gas conversion eff. 65 %

78 g CDW/m^3reactor·h

Continuous mode

Monoculture: *Sulfuricurvum spp*.

H_2 gas conversion eff. 81 %

375 g CDW/m^3reactor·h

DRIED PRODUCT

Single cell protein

Crude protein content = 71 %

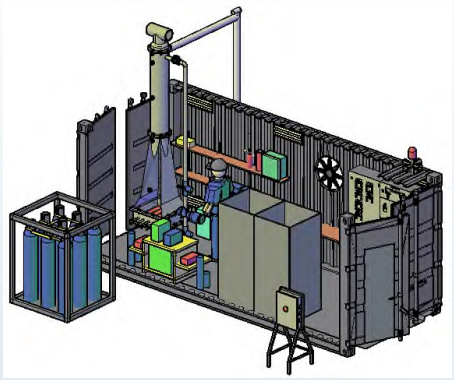
Nutritional properties:

comparable to high-quality fishmeal

SOURCE: MATASSA, S. ET AL., WATER RESEARCH, 101 (2016), 137 -146

Power-to-protein project

Under the TKI Water Technology Programme



Early 2016
Desk study

Late 2016
Pilot plant design
and building

2017
Pilot test start
on site of WWTP

Power-to-protein desk study

Potential and necessary resources

	Avecom (2014)	Amsterdam-West reject water sludge digestion	WWTP's Amsterdam influent water
available: ammonium NH_4-N	196 kg	by air stripping **1,235 tons/yr**	total potential **4,670 tons/yr**
hydrogen H_2	786 kg	5,000 tons/yr	18,900 tons/yr
carbon dioxide	3,309 kg	21,000 tons/yr	79,400 tons/yr
oxygen	2,924 kg	18,400 tons/yr	69,600 tons/yr
Production SCP	1,000 kg	6,300 tons/yr	24,000 tons/yr

Based on reaction stoichiometry

$21.36\ H_2 + 6.21 O_2 + 4.09\ CO_2 + 0.76\ NH_3 \rightarrow C_{4.09}H_{7.13}O_{1.89}N_{0.76} + 18.7\ H_2O$

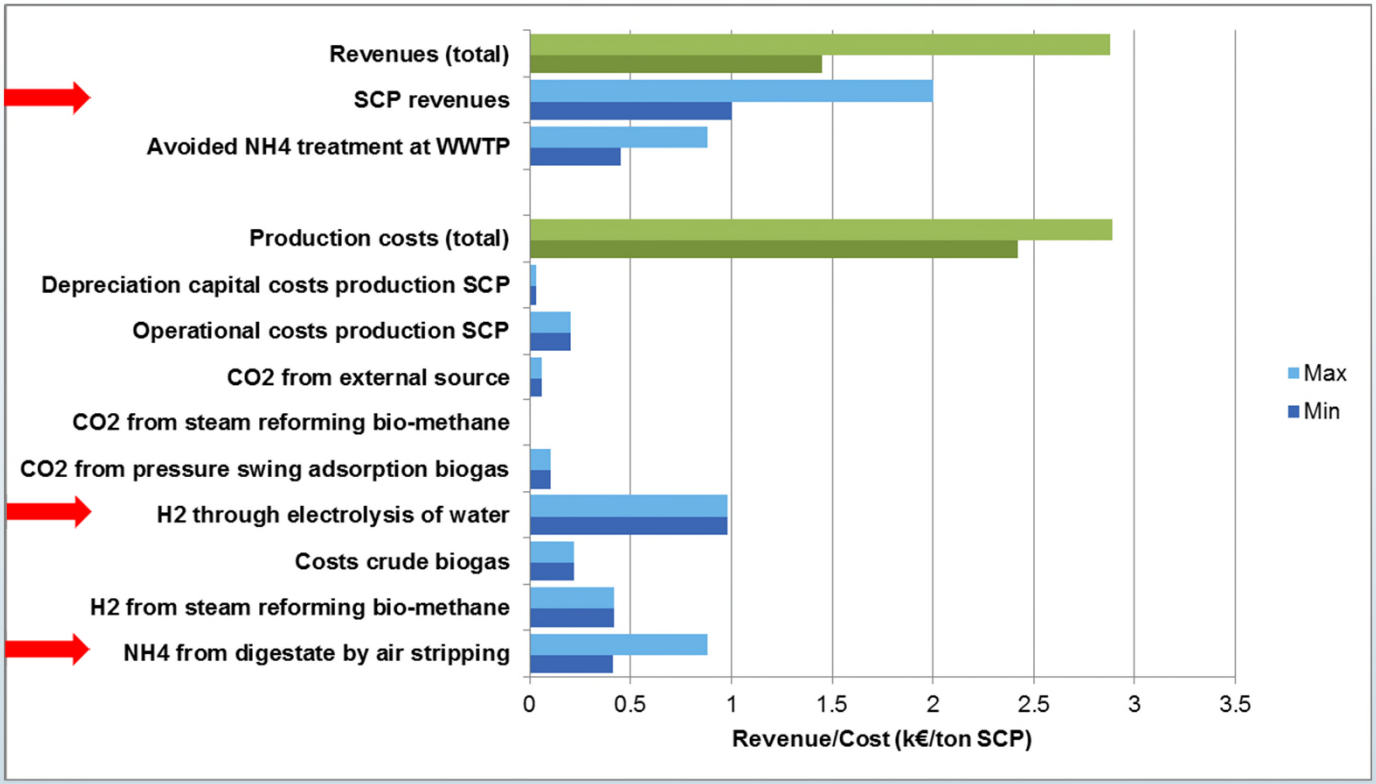
Equals 36 % of the net protein demand of the cities population!

Power-to-protein desk study

Costs and revenues (in k€/ton SCP)

SCP revenues dependent on quality aspects

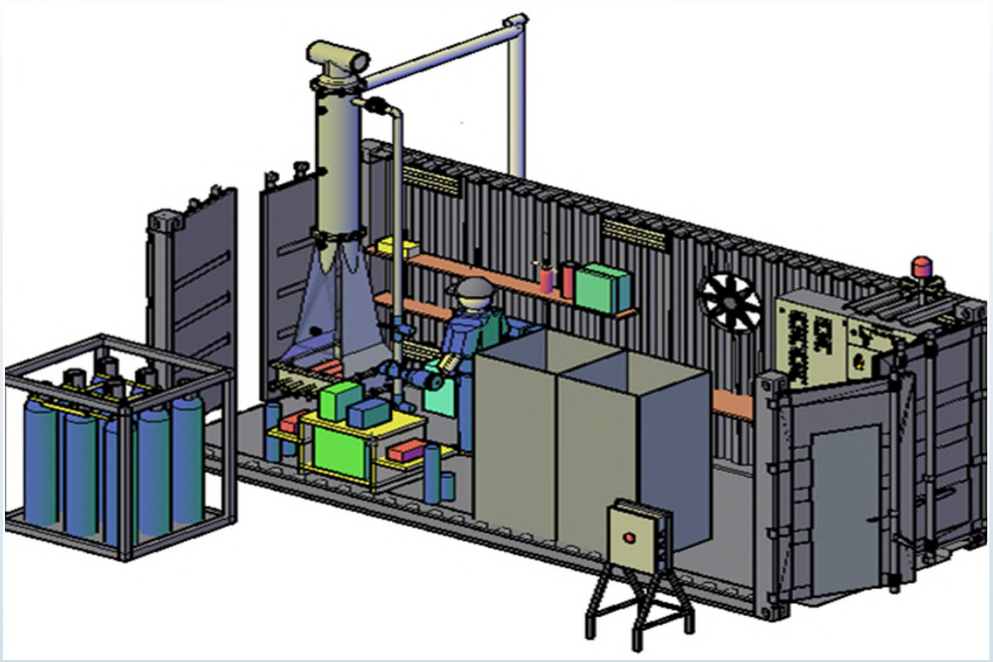
hydrogen production & ammonia recovery are cost decisive



Power-to-protein pilot study

Upscaling from 5 to 400 liter reactor volume

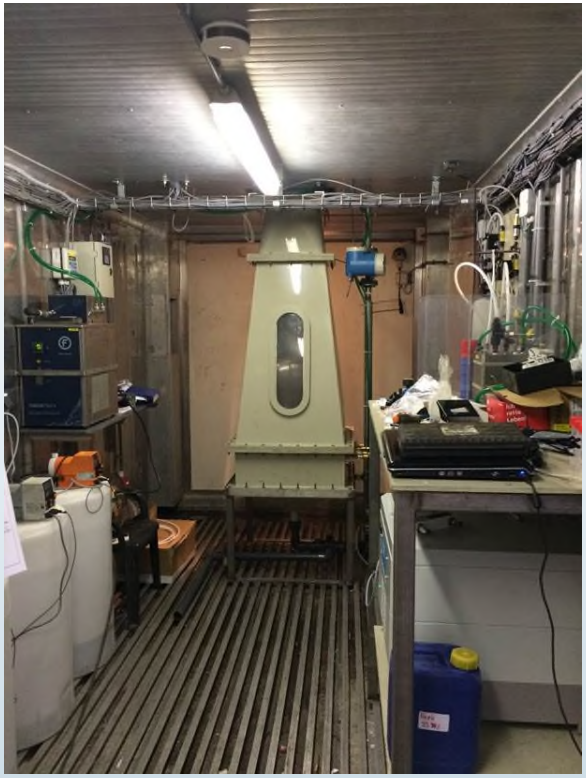
- Ammonia recovery by air stripping (NAR pilot plant from Nijhuis Water Technology)
- H_2 and O_2 produced on site with water electrolysis
- Reactor volume 400 L
- Expected productivity of 1 to 2 kg dry biomass per day
- 2 testing sites



Power-to-protein pilot study

Pictures on location

POWER-TO-PROTEIN REACTOR AT SWTP ENSCHEDE

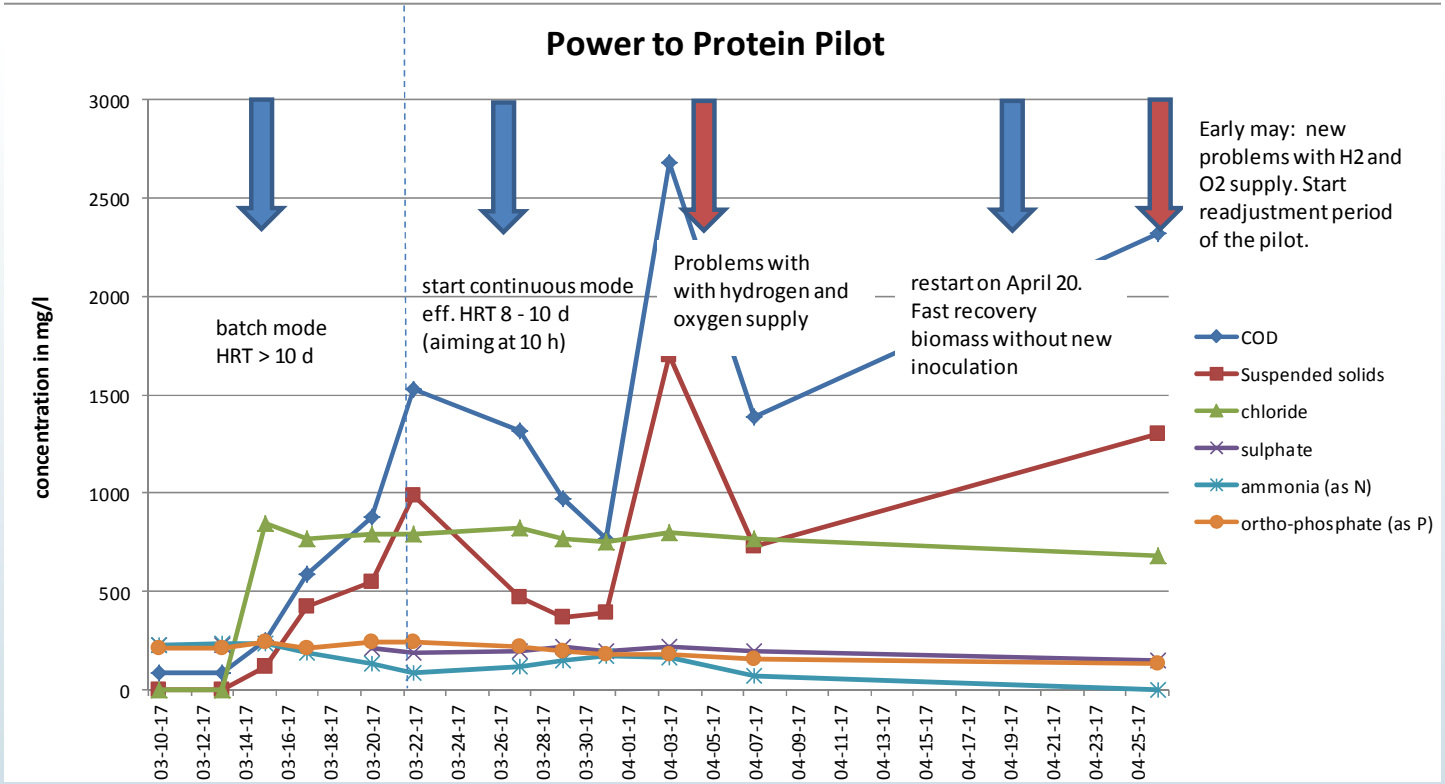


ELECTROLYSIS CELL

Power-to-protein pilot study

First results

Reactor content on March 22 2017



Power-to-Protein website

All reports/publications available

See www.powertoprotein.eu

- About
- Research partners
- Research Programma
- Publications
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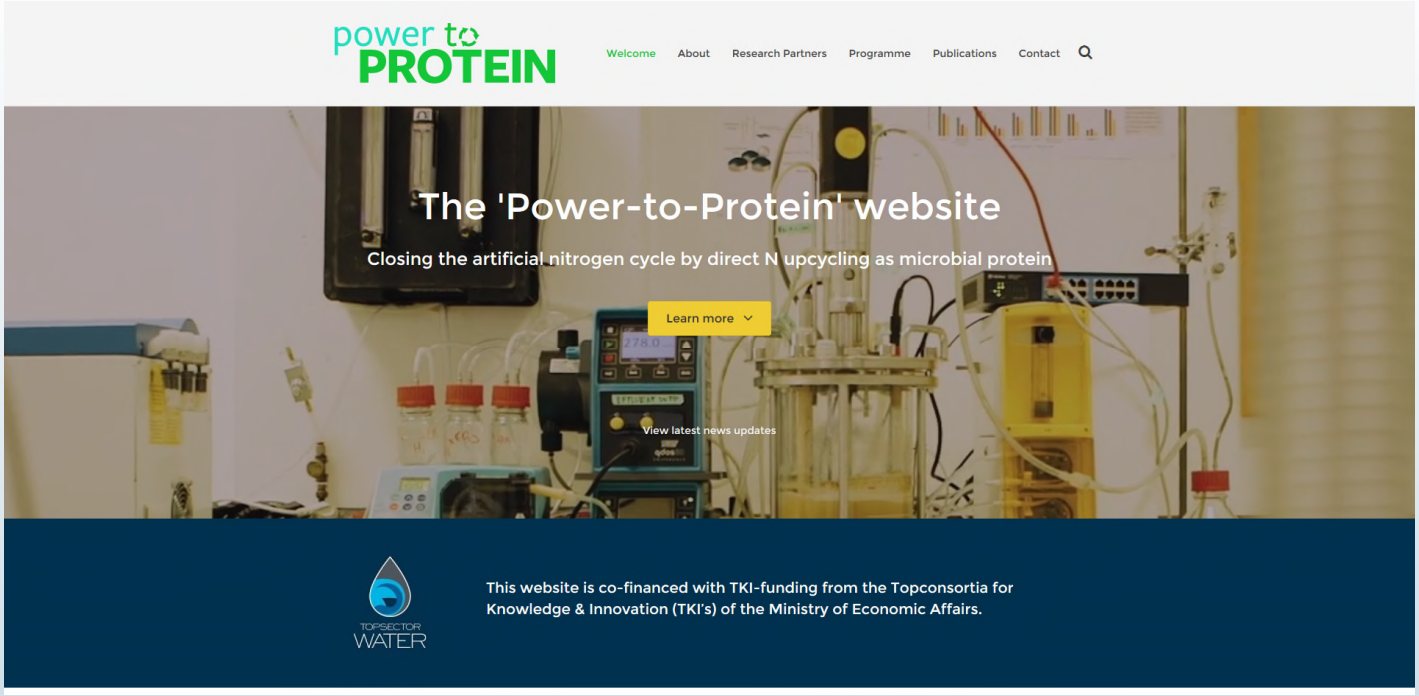

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