Feasibility of the Power-to-Protein concept in the circular economy of the city of Amsterdam

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inspiring change


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SUSTAINABLE WATER CYCLE

- Sustainable use of water resources
- Preparing for climate change
- Water technologies for sustainable energy
- Resource recovery

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The idea of power-to-protein

Avecom Belgium/ Prof. Dr. Willy Verstraete & Silvio Matassa M.Sc.

May 2015, cover ES&T

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

Is this how we feed 10 billion people on this planet in 2050?

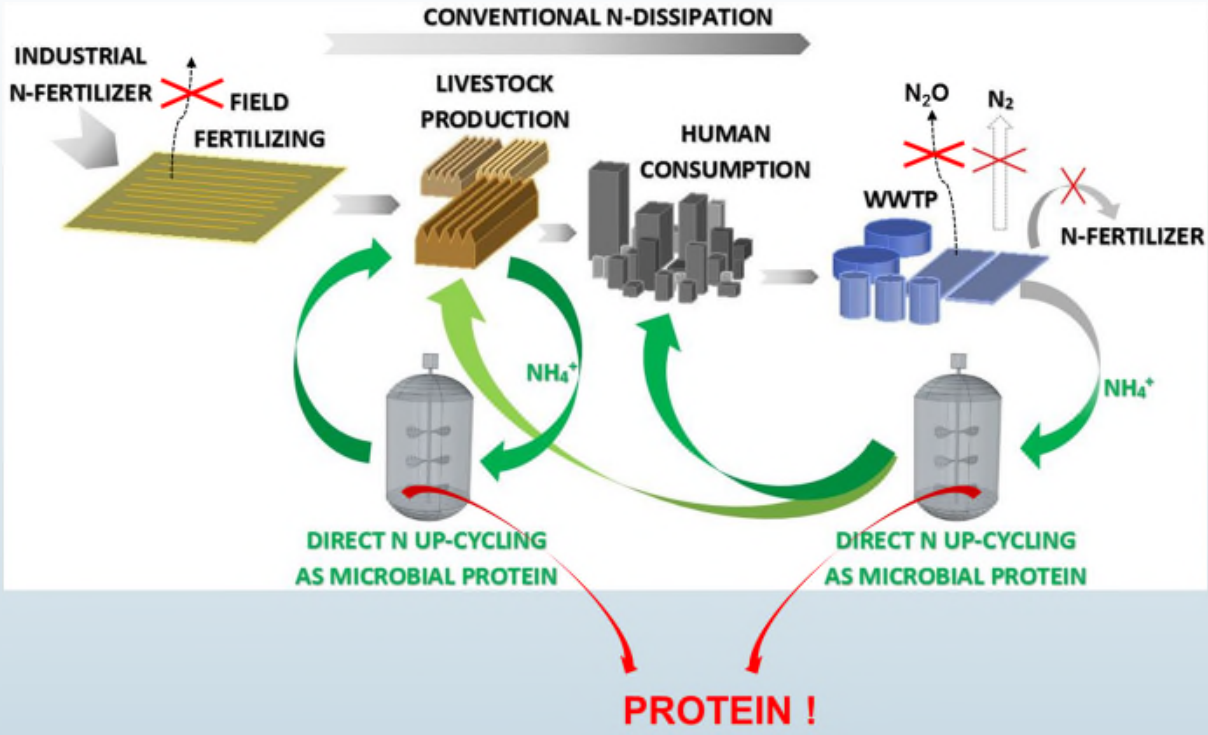
Power-to-protein concept

Direct upcycling of ammonia as microbial protein

The artificial nitrogen cycle is very inefficient

Haber Bosch → reactive N:
450 million tons/yr enter our biosphere

Only 10% becomes edible protein; 90% is lost to the environment



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

Power-to-protein concept

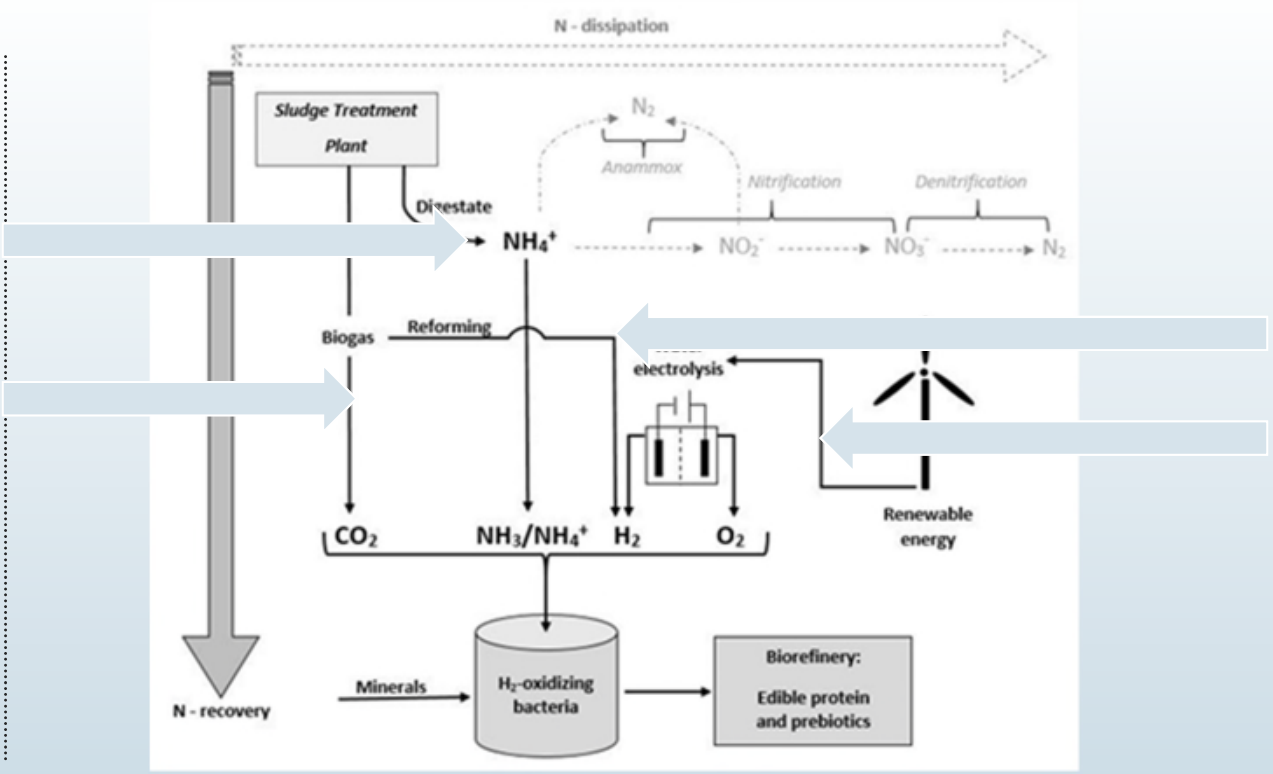
All sources from the waste water chain

NH_4^+ from reject water sludge digester

CO_2 from biogas refinery to biomethane or other industrial sources

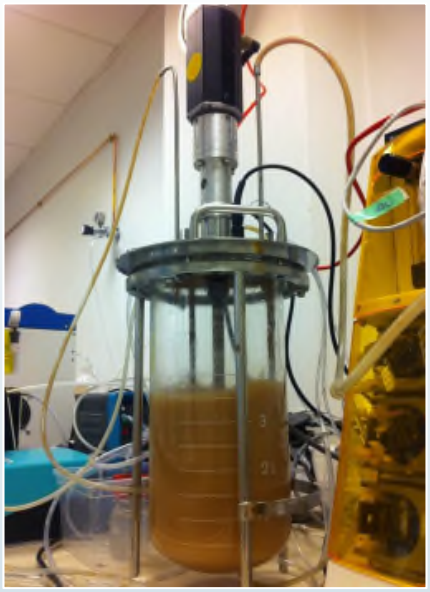
CO_2/H_2 from steam methane reforming of biogas

H_2 from renewable energy on/off site (hydrogen economy)



Power-to-protein concept

Laboratory set up and results



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

PtP project Amsterdam

The potential of the PtP-concept in the water cycle of Amsterdam

Desk study with following goals:

- Create a link with relevant sources in the urban zone of the city of Amsterdam
- Determine the technological and economic feasibility of the Power-to-Protein concept
- Define relevant research questions that have to be answered

Amsterdam Locations WWTP	Number of inhabitants connected	N-load (tons/yr)	ammonia load (tons/yr)
WWTP West	564,113	3,009	3,876
WWTP Westpoort	265,510	1,416	1,824
Total	**829,623**	**4,425**	**5,700**

PtP Project Amsterdam

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	3309 kg	21.000 tons/yr	79.400 tons/yr
oxygen	2924 kg	18.400 tons/yr	69.600 tons/yr
Production SCP	1,000 kg	6,300 tons/yr	24,000 tons/yr

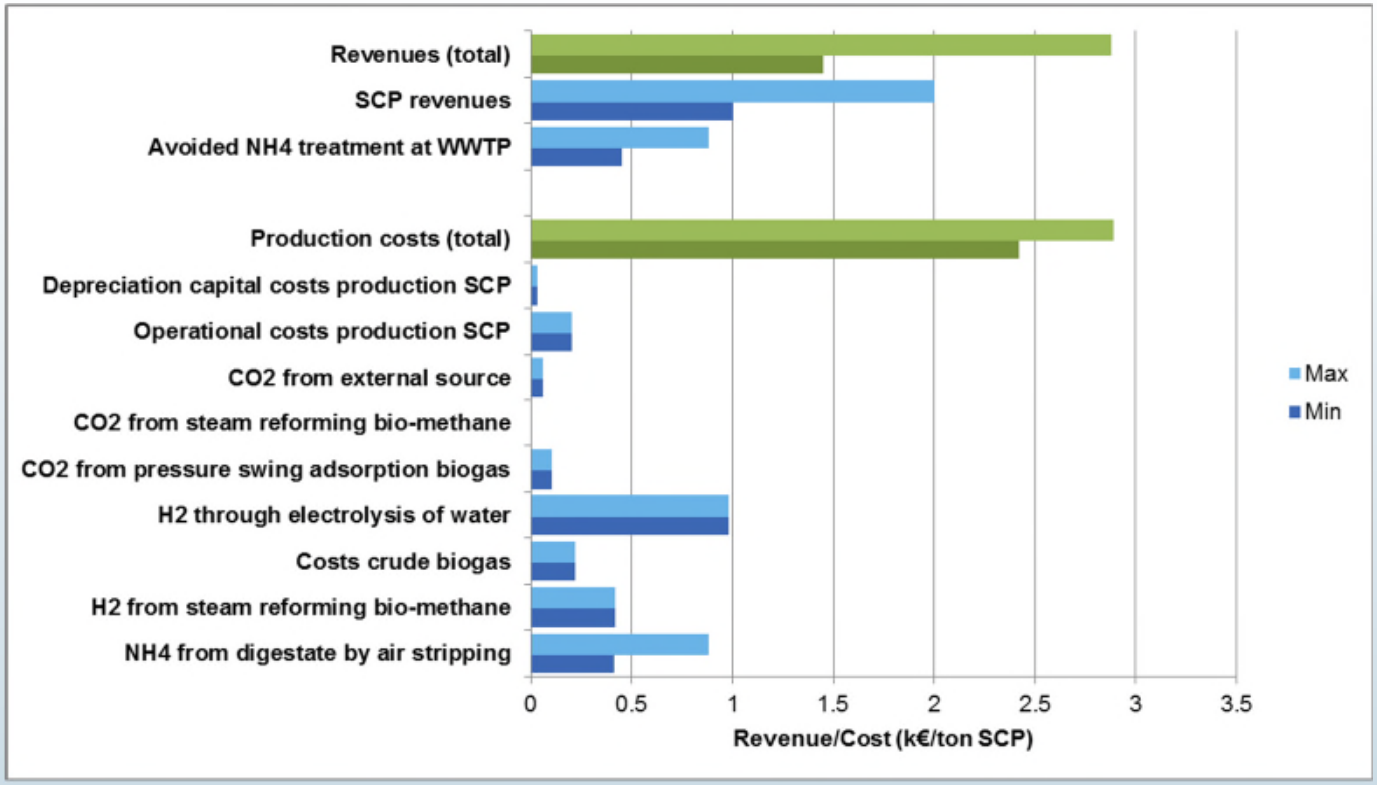
Based on reaction stoichiometry

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

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

PtP Project Amsterdam

Costs and revenues (in k€/ton SCP)



Power-to-Protein concept

Conclusions

The potential for production of SCP from sources in the waste water chain is high

There is a good economic potential as well from a broader perspective

There is a need for efficient methods to extract ammonia from the waste water chain

Other relevant aspects:

- Introduction novel food: complex, time consuming and expensive/ focus on animal feed
- Protein characterisation: nutritional value, digestibility, allergenicity
- Public acceptance

Power-to-Protein concept
Follow-up

Follow up research:

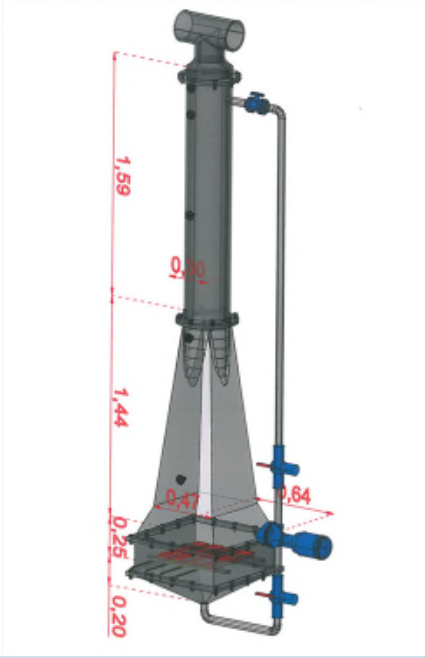
- Upscaling of the reactor
- Demonstration on site
- Characterisation of the SCP produced

Project partners:

Waternet, AEB, Waterboard Vechtstromen, Barentz Agri Nutrition, Avecom, KWR.

See www.powertoprotein.eu

DESIGN PTP REACTOR



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