



Green Fish Farm®

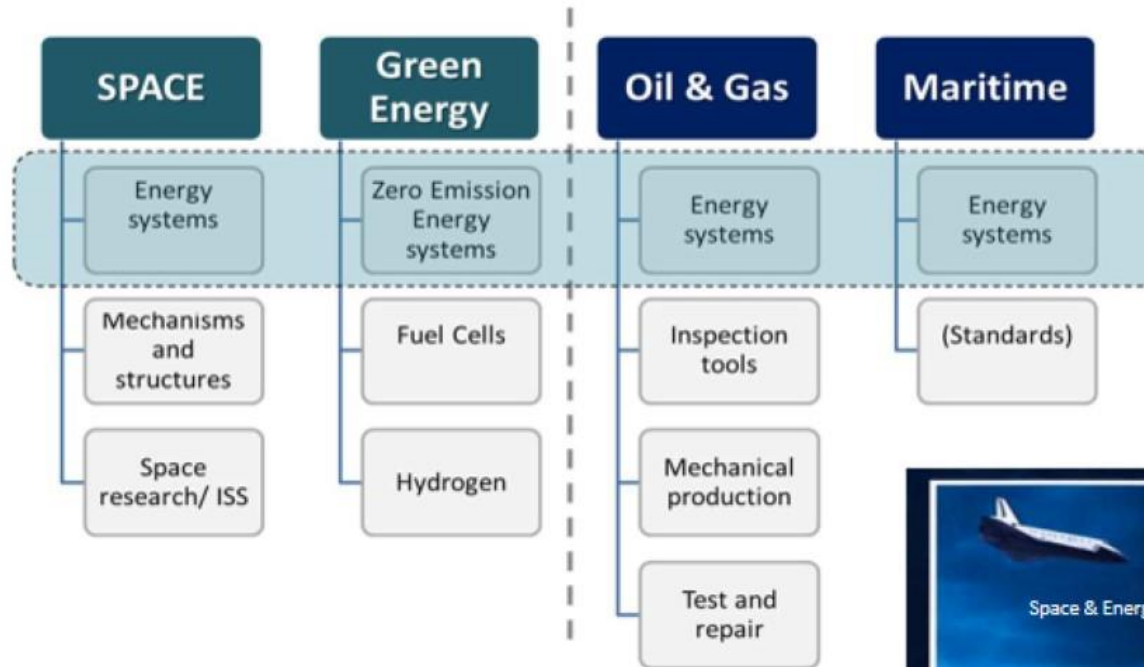
Lands meets Ocean

15.09.2020

cmr

Christian Michelsen Research

- Dates back to CMI/ Odd Dahl
- Established as legal entity in 1988
- Part of NORCE Innovation
- 48 employees from 6 countries
- Prototype development – from idea to product
- Highly skilled workforce and spectacular projects from space to the seven seas



cmr Prototech



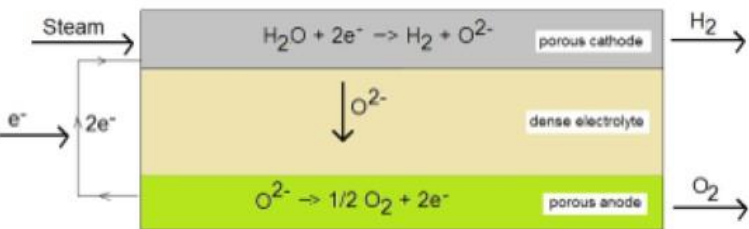
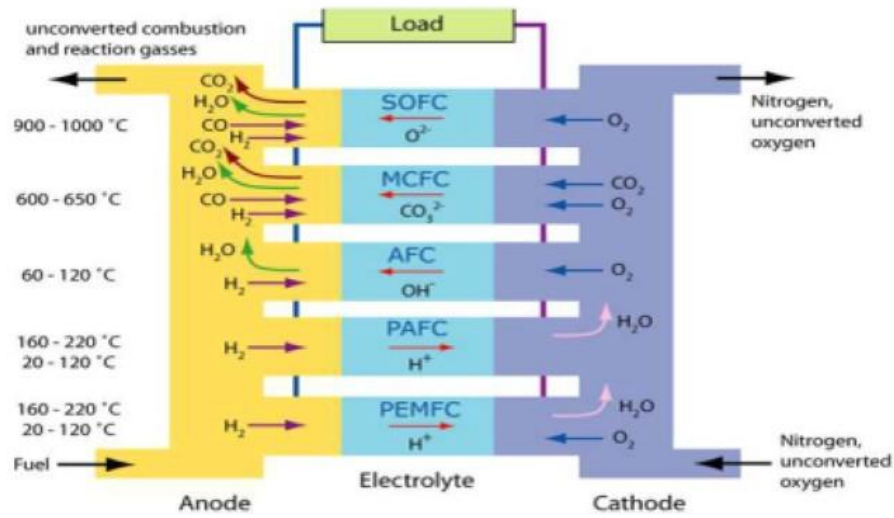
From Space to the Seven Seas



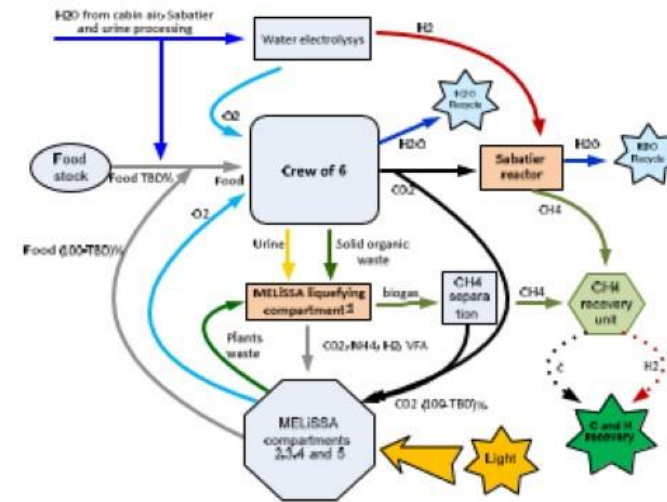
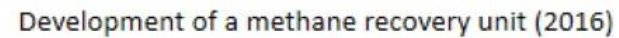
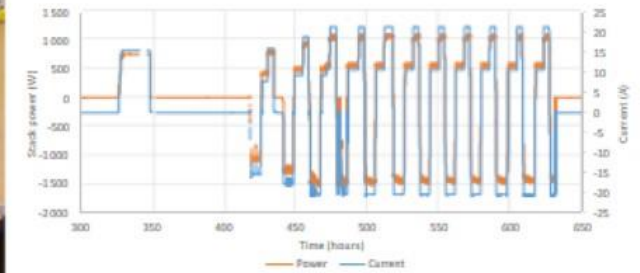
1988

2018

Fuel Cells. Electrolysis. Pyrolysis.



Reversible SOFC (2014)

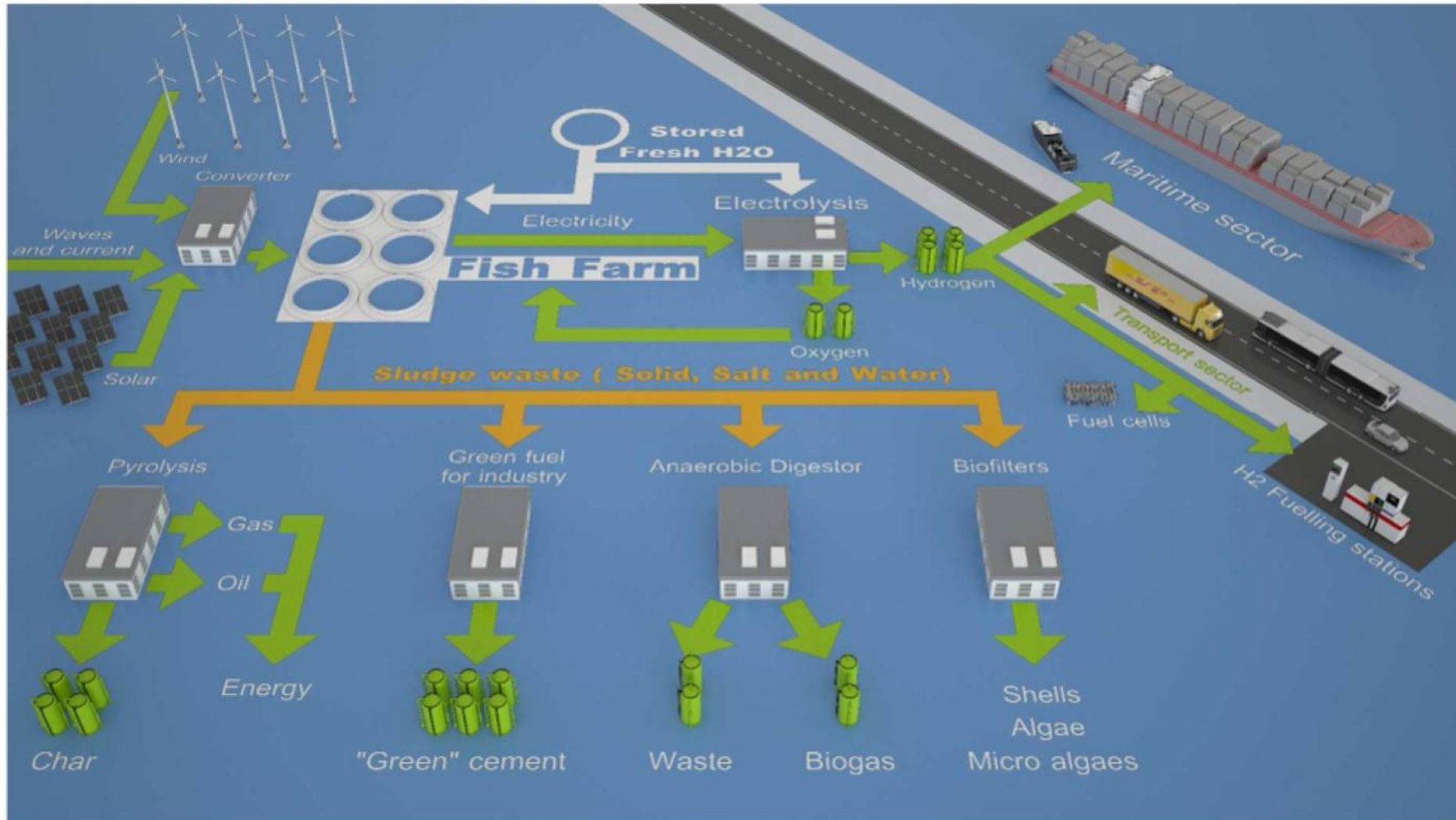


Pyrolysis, 800 C



Gasification, 800 C

Green Fish Farm®



Fish Sludge Potential

If Norwegian fish farming industry collects and re-uses the sludge from 1 million tones salmon/year to produce biogas then 70-190 million m³ CH₄ could be produced, equivalent to 0.7-2TWh energy¹.

¹[http://www.bioforsk.no/ikbViewer/Content/117792/Bioforsk%20Rapport%209%20\(27\)%202014%20-%20Fiskeslam%20frå%20oppdrettsanlegg.pdf](http://www.bioforsk.no/ikbViewer/Content/117792/Bioforsk%20Rapport%209%20(27)%202014%20-%20Fiskeslam%20frå%20oppdrettsanlegg.pdf)

2018: Norwegian aquaculture production was approx. 1.6 Mtonnes.

Produksjon laks og regnbueørret	Biomasse (tonn)	Slam (10 % TS, tonn)	Slam (90 % TS, tonn)
Produksjon 2017	1 300 000	2 145 000	238 333
Dobling av dagens produksjon	2 600 000	4 290 000	476 667
Femdobling av dagens produksjon	6 500 000	10 725 000	1 191 667

<http://fisk.no/attachments/article/6572/landbasert-lakseoppdrett-analyse.pdf>

Biogas potential by 2050 = 4.1 TWh

	Antall	GWh	MWh/innbygger	Prosentvis endring 2008-20		
Norge i alt ¹	4 799 252	45 325,7	9,4	1,3	3,5	;
0301 Oslo	575 475	4 534,9	7,9	2,7	2,7	;
1201 Bergen ¹	252 051	2 033,4	8,1	1,7	-1,7	;
1601 Trondheim ¹	168 257	1 307,1	7,8	1,9	0,3	;
1103 Stavanger ¹	121 610	983,9	8,1	1,7	0,9	;
0219 Bærum ¹	109 700	961,3	8,8	1,4	4,7	;
1001 Kristiansand	80 109	659,6	8,2	1,5	2,6	;

²<https://www.ssb.no/energikomm>

500 000 tones of sludge annually discharged is equivalent to the waste generated by 20 million people.

³<https://www.dagbladet.no/kultur/hiv-driten-pa-land-erna/71486953>

2018 - total sludge volume from salmon aquaculture is up to 1.5 million m³/year. Only 5-10% is collected, processed and utilized (organic fertilizer in agriculture)⁴.

[havbruksn%C3%A6ring.pdf](#)

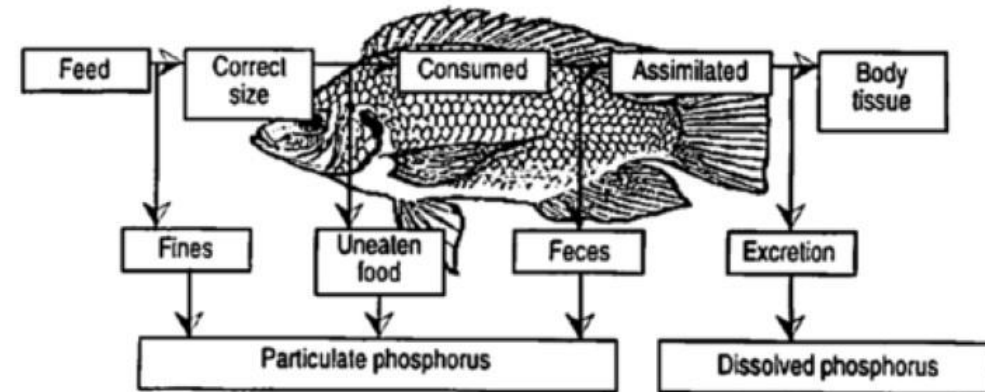
⁴https://siomatnorge.no/wp-content/uploads/2019/08/BI_2019_En-konkurransedyktig-og-kunnskapsbasert-

Phosphorus dilemma

P finite resource that we are 100% dependent on that is currently wasting it in a way that creates pollution.

finite resource

pollutant



Essential for life!

Mineral P for chemical fertilizers from phosphate rock (Morocco, W. Sahara)

1/3 of P imported to Norway used for fish feed production

P peak 30 to 100 years. P demand will increase 50-100% by 2050

36% of the total P eaten is retained in the fish, 10% is excreted as dissolved waste, 54% is excreted as solid waste in faeces

Fish farming - largest source of P emissions generating about 9 000 tones/year ends up in the sea → 73% of the total addition of P to coastal waters in Norway

45 132 t P - emission of P by 2050 in Norway

Eutrophication of marine waters is not considered a problem (water rapid turnover rate) nutrients are quickly dispersed over large areas.

Finding new P sources

- new business,
- new jobs,
- cut pollution,
- secure life



Quantifying Circular Economy in Norway:

- Circularity Metric is 2.4%.
- One of the highest global rates of consumption ~ 44.3 t/person/per year
- Of all the materials consumed in the country > 97% are not cycled back into the economy

This is Norway's Circularity Gap.

Of all the non-metallic minerals, fossil fuels, metals and biomass that enter the world's economy each year, just 8.6% are cycled back

SUSTAINABLE SEAS, SLASHING FOOD WASTE

In an excellent example of the circular economy in practice, Norway based Ocean Forest,¹⁸ founded by Lerøy Seafood Group and the environmental organisation Bellona, is pushing for sustainable food production and reduced CO₂. The company uses excess nutrients in the sea from fish farms—phosphorus, nitrogen and CO₂—to cultivate sugar kelp and mussels. These can, in turn, be used for human consumption, feed and renewable energy—as well as the absorption of CO₂. Startup AlgaePro, meanwhile, is developing a technology to cultivate microalgae, which can be used for feed in aquaculture. The process uses bio waste from municipal waste management, as well as CO₂ and waste heat. The company hopes it can commercialise microalgae cultivation, therefore promoting a circular bioeconomy.

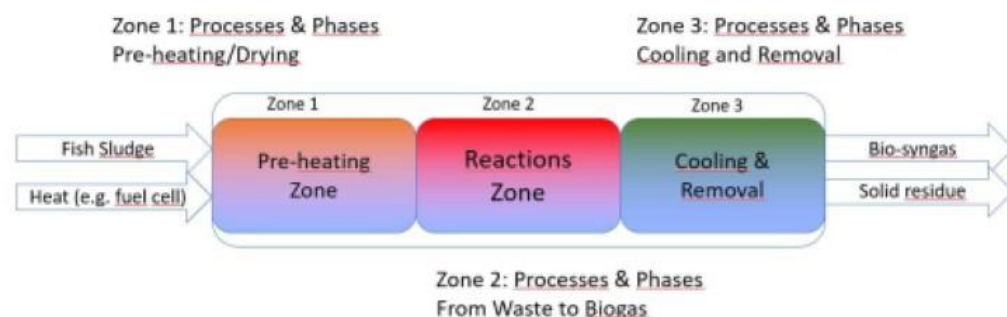
Closing the Circularity Gap – 6 «what-if» scenarios to rely less on linear economy

- (1) Circular construction
- (2) Total transition to clean energy,
- (3) Circular food systems,
- (4) Green transport system,
- (5) A strong repair, reuse & recycling economy
- (6) Circular forestry and wood products.

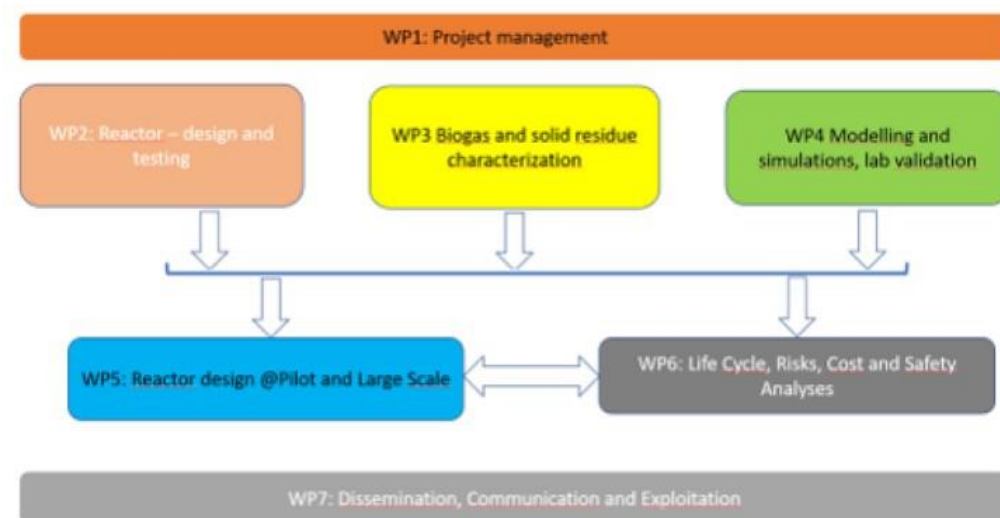
Each scenario boosts circularity and reduces consumption in Norway, but when combined:

- Circularity Metric 2.4% → 45.8%
- Reduce consumption, material footprint by 64.8%.
- Slash C emissions from consumption by 63%.

MAP-aG development - IPN (NFR) project



Work Package	Hours	Cost
WP 1 Management	1534	1687400
WP 2 Testing MAP-aG Reactor	3850	4700000
WP 3 Characterisation	950	1465000
WP 4 Modelling and Simulations	3000	3300000
WP 5 Design pilot scale reactor/full scale	2900	3190000
WP 6 Preliminary LCA, LCC, Risks, Safety	800	880000
WP 7 Dissemination and Communication	700	770000
Total	13734	15992400



Deadline: 15.oct. 2020

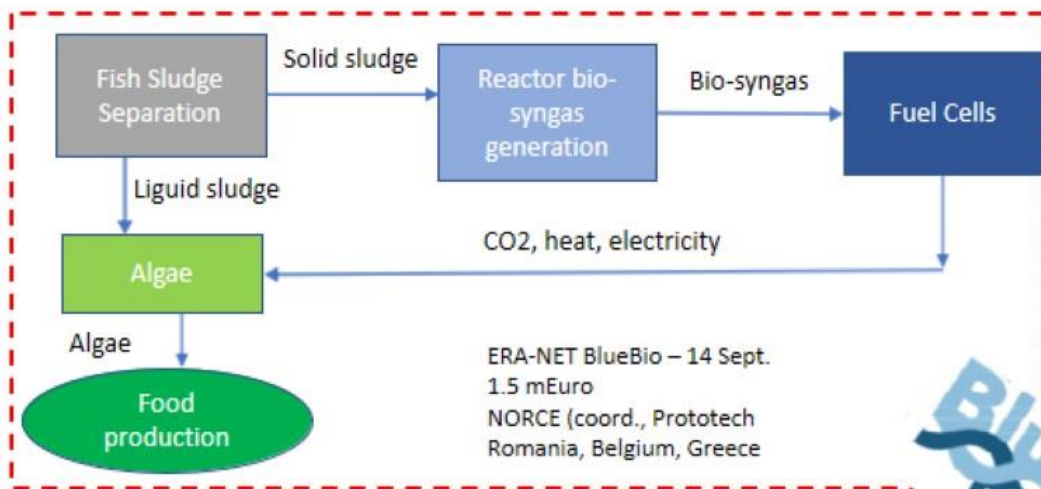
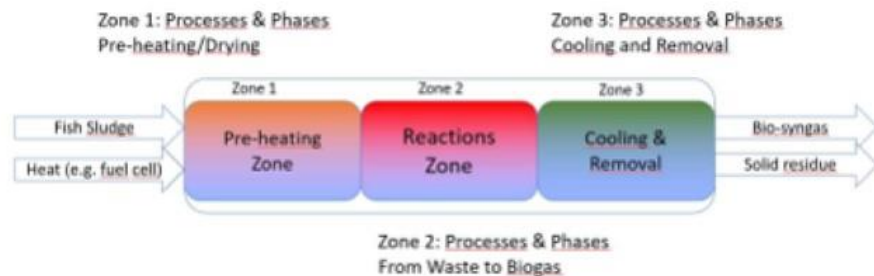
5 mNoks cash/in-kind, 11mNOKs funded via NRC

3/4 full time positions at Prototech

Subcontracting: LCA/LCC, Safety, Molecular Modelling, Analyses

Additional cost: softwares, lab rental, equipment, materials, chemicals, dissemination/communication

Sludge to Value



European Green Deal call

Call area 1: Increasing climate ambition: cross-sectoral challenges

Call area 2: Clean, affordable and secure energy

Call area 3: Industry for a clean and circular economy

Call area 4: Energy and resource-efficient buildings

Call area 5: Sustainable and smart mobility

Call area 6: Farm to Fork

Call area 7: Restoring biodiversity and ecosystem services

Call area 8: Zero-pollution, toxic-free environment

Call area 9: Strengthening our knowledge in support of the European Green Deal

Call area 10: Empowering citizens for transition towards a climate neutral, sustainable Europe

Call area 11: Accelerating the clean energy transition and access in partnership with Africa

Internal Workshop: early October
Deadline: end January 2021

The European Green Deal Call

Farm-to-Fork

Full title : "From farm to fork: testing and demonstrating high impact innovations to address food system challenges in a place-based context."

An Innovation Action (IA), that calls for demonstration projects to test, pilot and showcase place-based, innovative system solutions to **4 pressing food systems' challenges**, and resulting in **4 targeted impacts**:

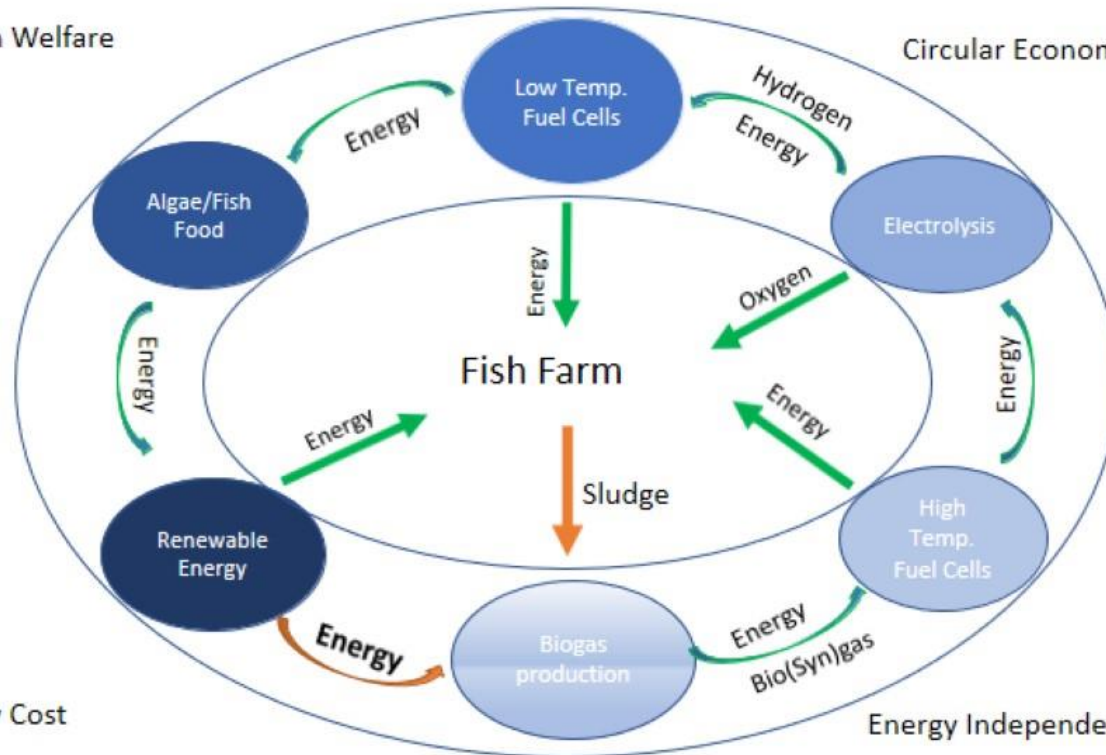
- 1) (a) achieving climate neutral farms, and/or b) achieving climate neutral food businesses;
- 2) reduction of pesticides, antimicrobials, fertilizers and harmful nutrients, towards zero pollution
- 3) reduction of food loss and waste
- 4) shifting to sustainable and healthy diets, sourced from land and sea.

Circular Economy - GFF® - UNs Sustainability Goals



Fish Welfare

Circular Economy



Low Cost

Energy Independence



CREATE

Thank you for your attention
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