5th IBBA Workshop on high-value products from biogas systems – nutrient extraction and biorefinery approaches

Poznań, Poland, August 23rd - 24th, 2017

High-value products from Anaerobic Digestion-Norwegian experience

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Ongoing Projects:

- **Utilization of Waste from Marine Food Production to Regional Renewable Energy (RenEnerMar, 2016-2019)**

- **Wastewater and Organic Waste Treatment Facilities – Net Green Energy, Nutrients and Bio-products Producers (RESERVE1, 2017-2019)**

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HIGH-VALUE PRODUCTS FROM ANAEROBIC DIGESTION – NORWEGIAN EXPERIENCE

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Both projects will aim to increase use of organic resources for the production of valuable products:

- clean energy in form of biogas
- plant available nutrients
- intermediate products of anaerobic digestion
- fertilizer byproducts

Specific goals:

- Increase clean energy production through co-digestion processes at biogas existing plants;
- Produce VFAs and up-concentrate them, as platform chemicals for conversion into different bio-products;
- Produce valuable digestate fractions with enriched nutrient content (N:P:K)

Network

Funding sources

COWIfonden
Scandinavian R&D funding scheme

REGIONALT FORSKINGSFOND VESTLANDET
Norwegian regional R&D funding scheme

COWI
Private investor DK, NO, SE

Public sector (Municipal biogas plants)

Bergen's water/sewage company
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Rogaland's inter-municipal water/sewage company
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R&D Institute (Project management)

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Fundamental R&D

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Applied R&D

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End users application

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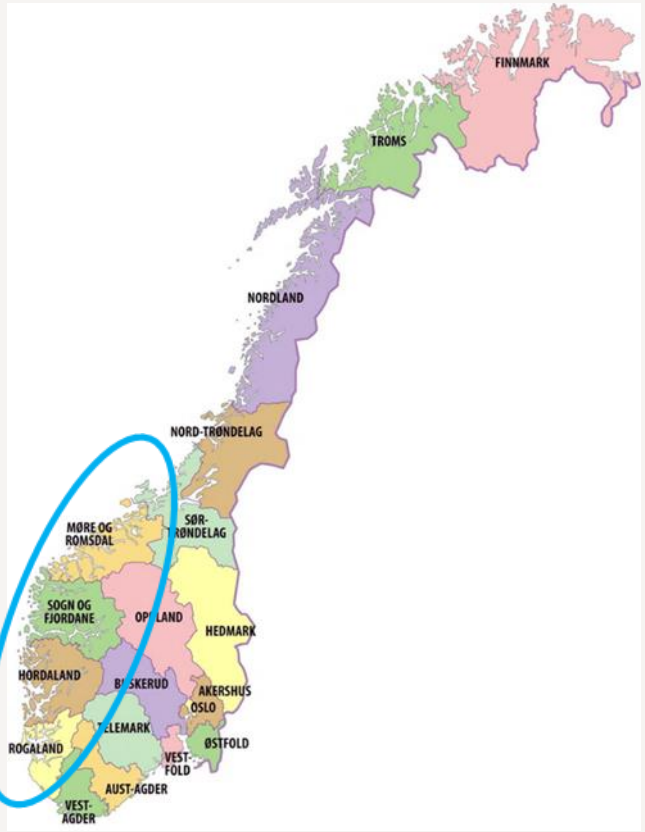
Utilization of Waste from Marine Food Production to Regional Renewable Energy (RenEnerMar, 2016-2019)

Main goal

Optimize utilization of organic resources from fish waste available in Western Norway to create public sector values by increasing production of renewable energy at municipal biogas plants.



Secondary objectives

Determine the optimal sampling ratios for fish waste, sewage sludge and food waste;
Determine the potential for increasing methane production using fish waste;
Improve quality and nutrient content in the residual product (P and N);
Build up local R&D expertise and establish cooperation between public users and suppliers of fish waste.

IVAR Stavanger Grødaland Biogas plant (GNA)

One of Norway's largest biogas plant for the reception of sludge and food waste (approx. 23 000 tones TS/year).

- ✓ 140 000 t/year - sludge
- ✓ 60 000 t/year – organic waste

- ❖ The main raw materials are food waste and sewage sludge. (73 and 24 % dry solids, in 2035).
- ❖ GNA and Sentralrenseanlegg Nord Jæren (SNJ) will be able to cover large parts of the fuel requirement for the region's bus fleet (2035, approximately 80 GWh - 200 buses).
- ❖ Digestate is used for soil mixtures (200 kg dewatered biorest for 1 ton of soil) or for fertilizer production (pellets)
- ❖ Goal: Optimization of phosphorus availability in the fertilizer product (including alternative N-sources in the form of nitrate and potassium (marine waste).

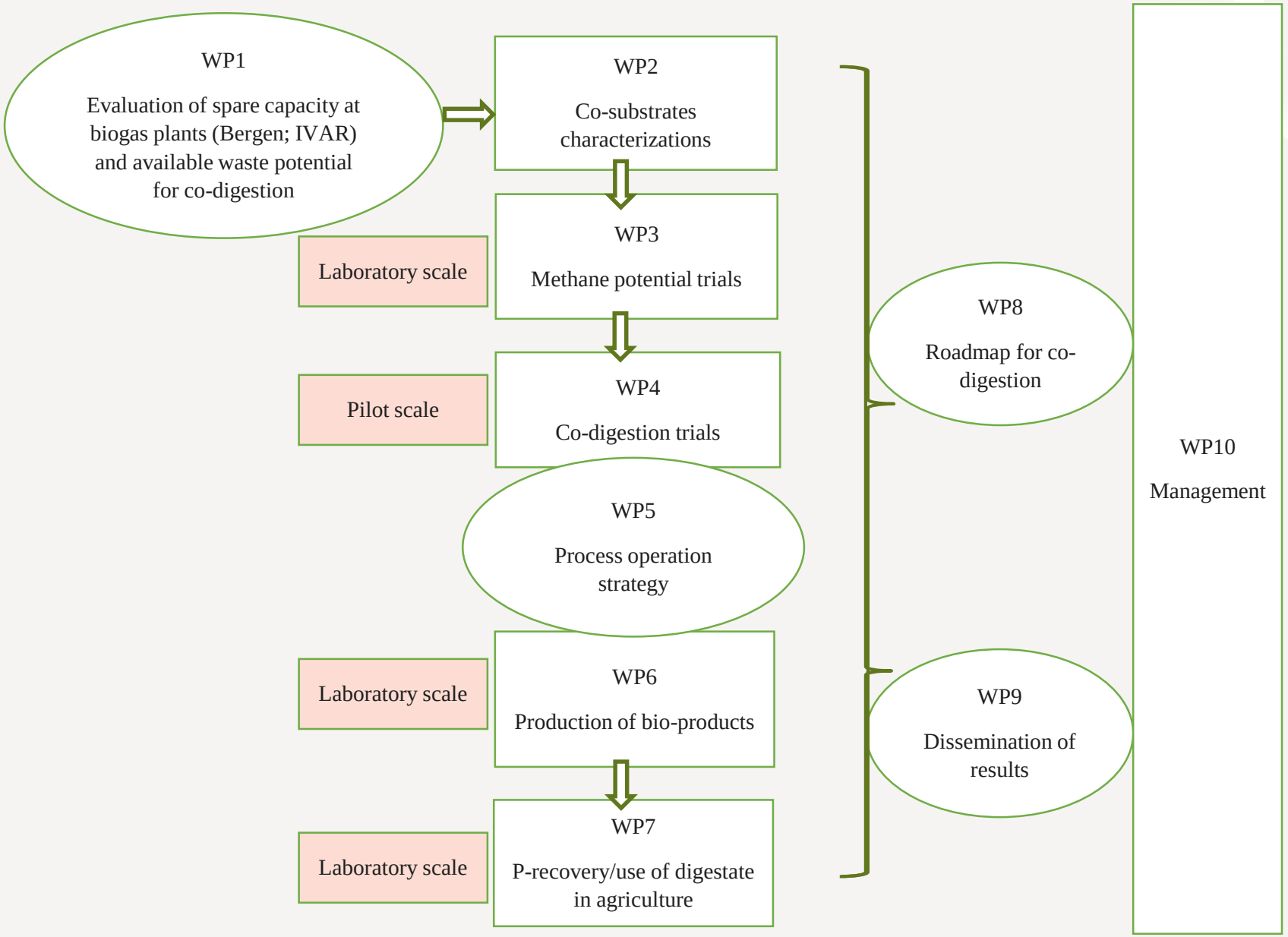
Bergen Kommune Rådalen Biogas plant

Access to "raw material":
- Sludge from wastewater treatment plant (10 000 tonnes)
- Septic sludge (100 tonnes)
- Food waste (938 tonnes)
- Oil and grease (200 tonnes)
- Fish waste
- Glycol (from Flesland)

- Designed for anaerobic treatment of food waste and sewage sludge as well as organic waste from the industry in the region.
- Energy value of approximately 25 GWh/year (ca. 80 buses)
- Use of digestate not decided yet – first option direct land use

- Goal – increase biogas production

Project plan



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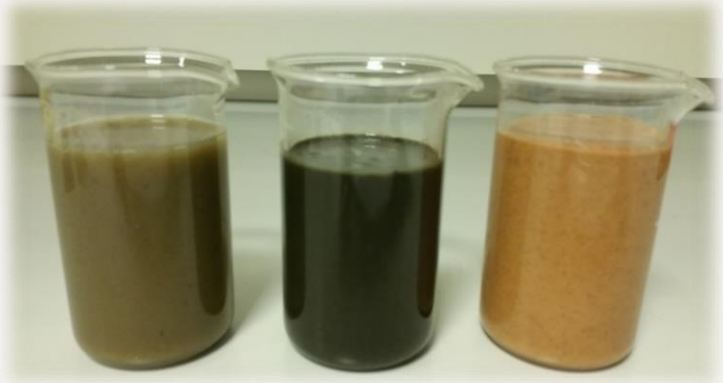
Current Research (WP1,2,3 RFF Vestlandet Project)

Substrates tested and used so far:

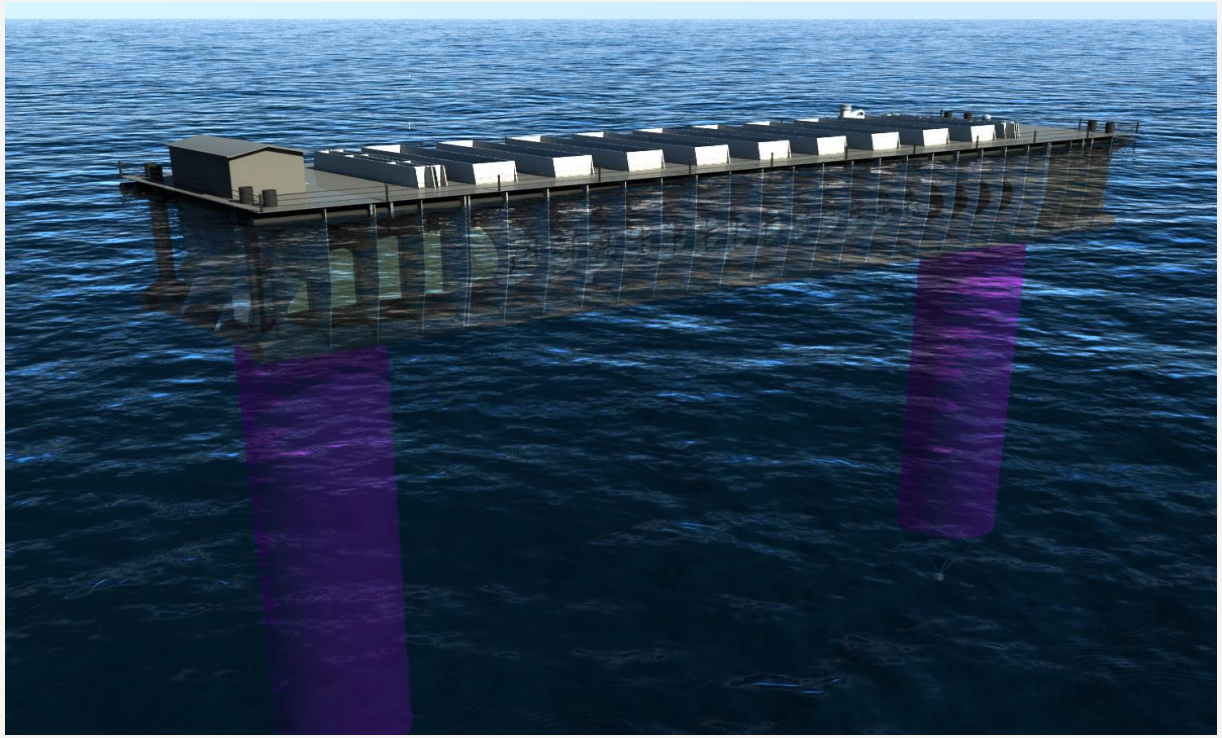
WWTP sludge:
- Bergen's municipal WWT plant
- IVAR's regional WWT plants

Fish sludge:
- Preline AS
- Lerøy Vest AS



LERØY

Preline Fishfarming System AS



The technology is designed for high water flow, low energy consumption and effective operations. Extended Smolt Farm is a pilot plant that has shown measurable effects on fish health, growth and quality.

The fish are protected in the 50 meter long enclosed tube, which has an elliptical cross-section. In each end there are propellers that create a natural water flow. Water from 25 to 30 meters in large quantities takes 3 to 5 minutes to pass through the system from end-to-end.

Current Research

Fish sludge

Preline:

- Sludge consisting mainly of fish faeces and excess feed.
- Treatment: sludge is filtered in a drum filter which is rinsed with fresh water
  Sludge/rinsing water is pumped to a sedimentation tank
  The sludge is thickened and stored until it is time to empty the tank.

Lerøy Vest:

- Very fresh fish sludge coming from fish of approx. 150 g.
- Composed of excess feed mostly, and some fish faeces.
- Treatment: Filtered in a drum filter on the plant, and pumped into a sedimentation tank floating in the sea.

Current Research

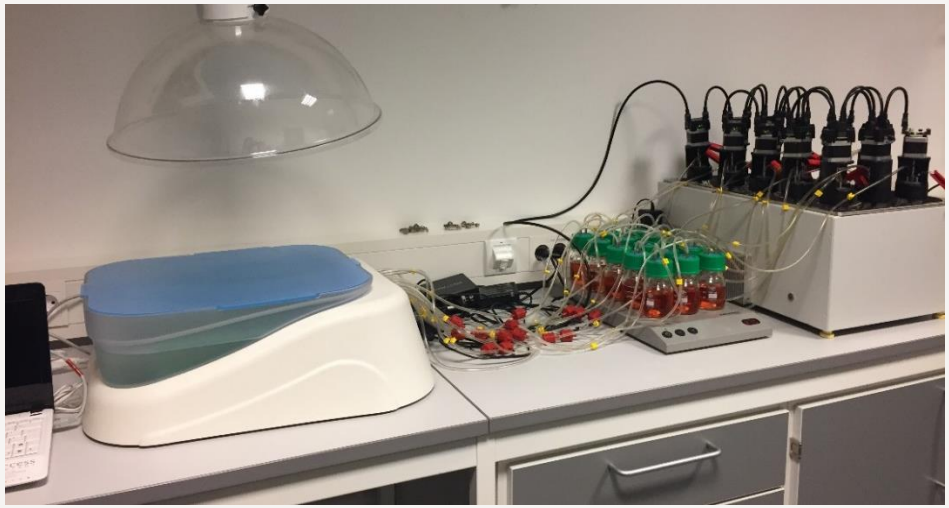
Characterisation

Substrat as received*	pH	Conductivity mS/cm	TS g/kg	VS g/Kg
Sludge Bergen wwtp	7,1	8,5	60,3	45,7
Sludge IVAR wwtp	5,3	4,5	24,5	21,0
Fish sludge Preline Fishfarming System AS	5,6	9,5	132,6	121,6
Fish sludge Lerøy Vest	4,7	4,4	103,9	91,8

*Substrates were later diluted/concentrated accordingly so to achieve final TS% in the substrates mixtures to employ for AMPTS in the range of 2-3 %

Biomethane potential trials

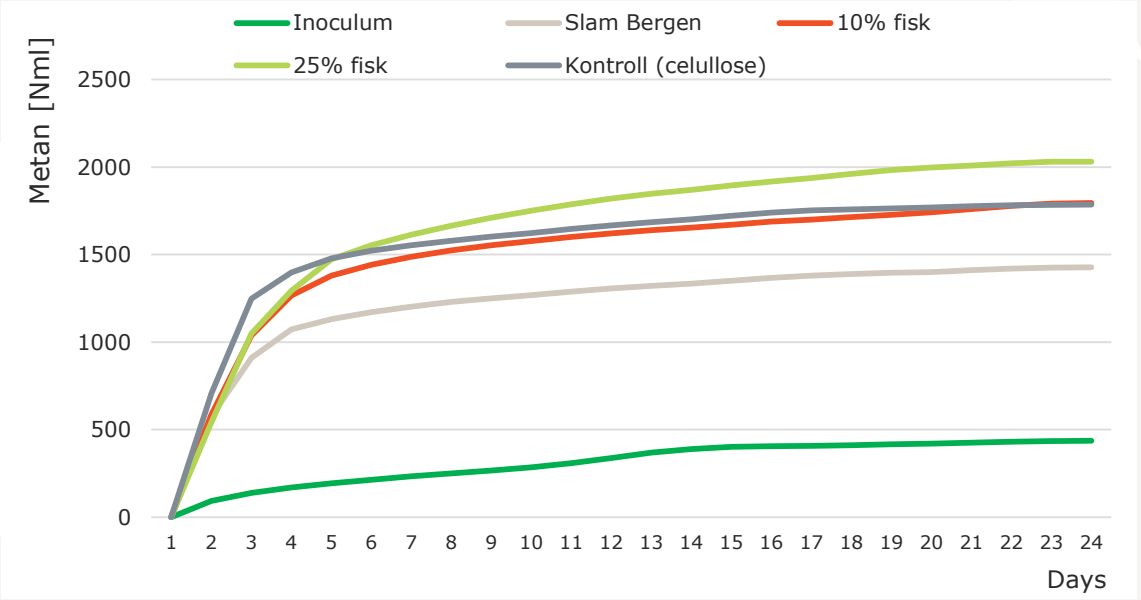
Batch biomethane potential (BMP) trials are performed using the AMPTS (II) Bioprocess Control System (Sweden).
The BMP of raw material (food/fish sludge) and its mixtures with sludge (primary, secondary and primary/secondary) will be estimated and inhibition concentrations will be determined.



Current Research

Results and ongoing research

- Results AMPTS (April 2017)
- testing:
  - Inoculum
  - Inoculum + Bergen sludge
  - Inoc.+ Mix 10% Preline/90% Bergen sludge
  - Inoc.+ Mix 25% Preline/75% Bergen sludge



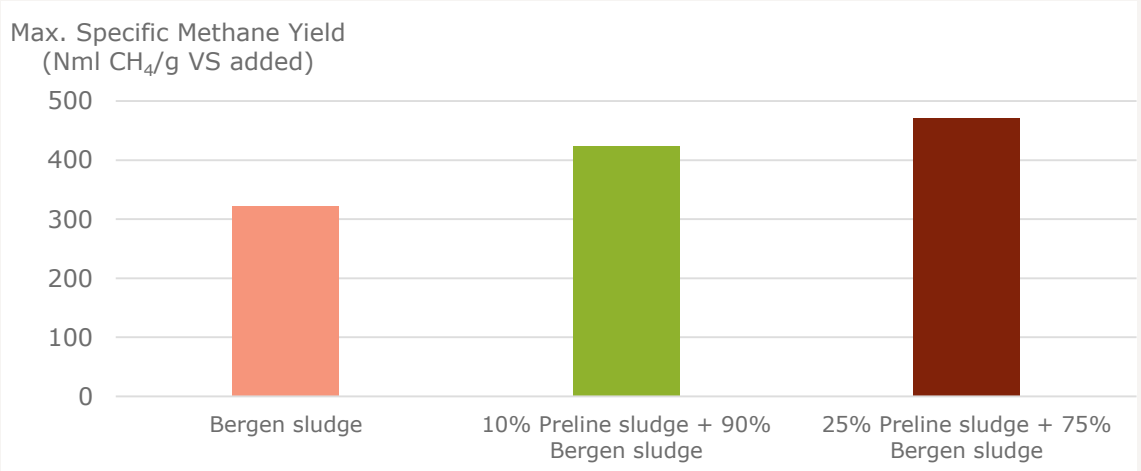
Addition of 25 % fish sludge (%volume) gave a 46 % increase in the methane production of Bergen sludge

25% fish: 472 Nml CH_4/g VSadded

0% fish: 323 Nml CH_4/g VSadded

Final pH: 8.05

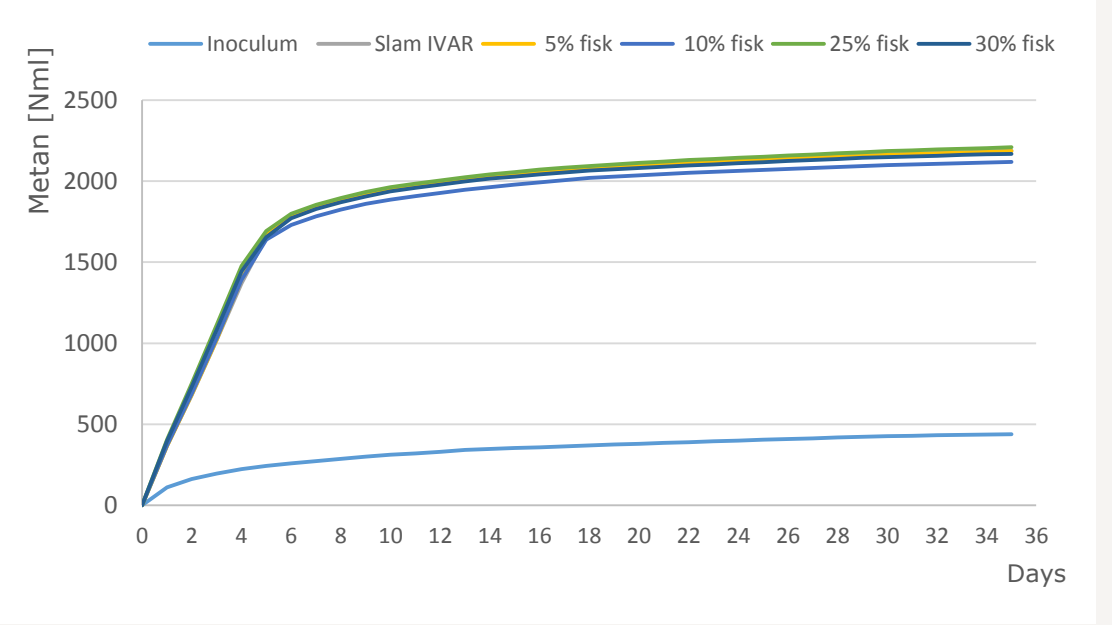
Final NH_4-N conc.: 3,3 g/100 g TS



Results and ongoing research

- Results AMPTS (June 2017)
- testing:

• Inoculum
• Inoculum + IVAR sludge
• Inoc. + Mix 5% Lerøy /95 % IVAR sludge
• Inoc. + Mix 10% Lerøy /90% IVAR sludge
• Inoc. + Mix 25 % Lerøy /75% IVAR sludge
• Inoc. + Mix 30 % Lerøy /70% IVAR sludge

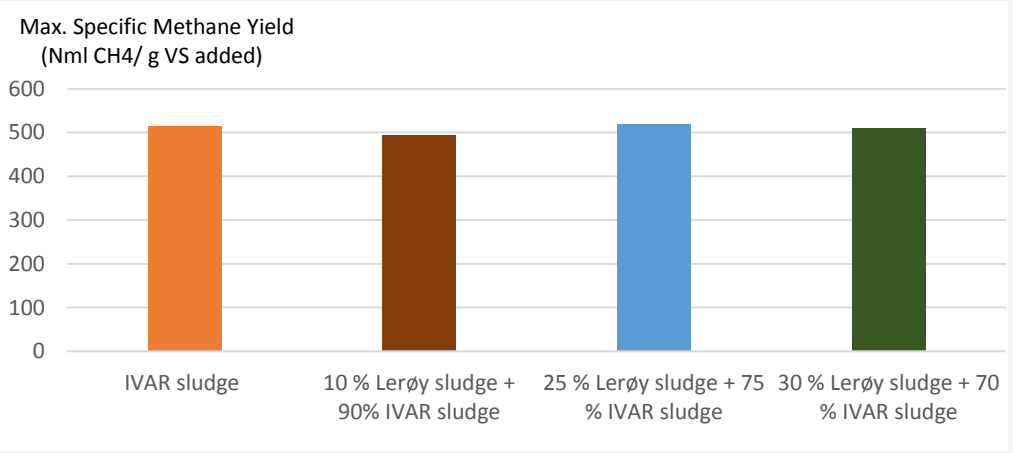


IVAR WWTP sludge was a remarkably good sludge for biogas production!

Addition of fish sludge did not change the methane yield from IVAR sludge

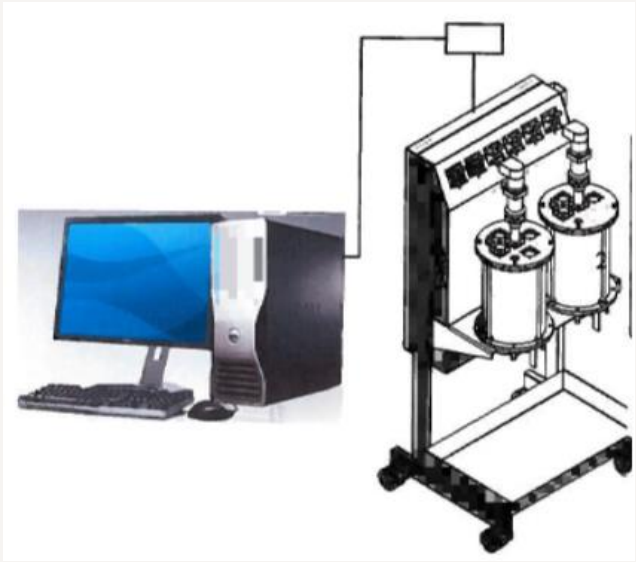
25% fish: 520 Nml CH_4/g VS_{added}

0% fish: 514 Nml CH_4/g VS_{added}

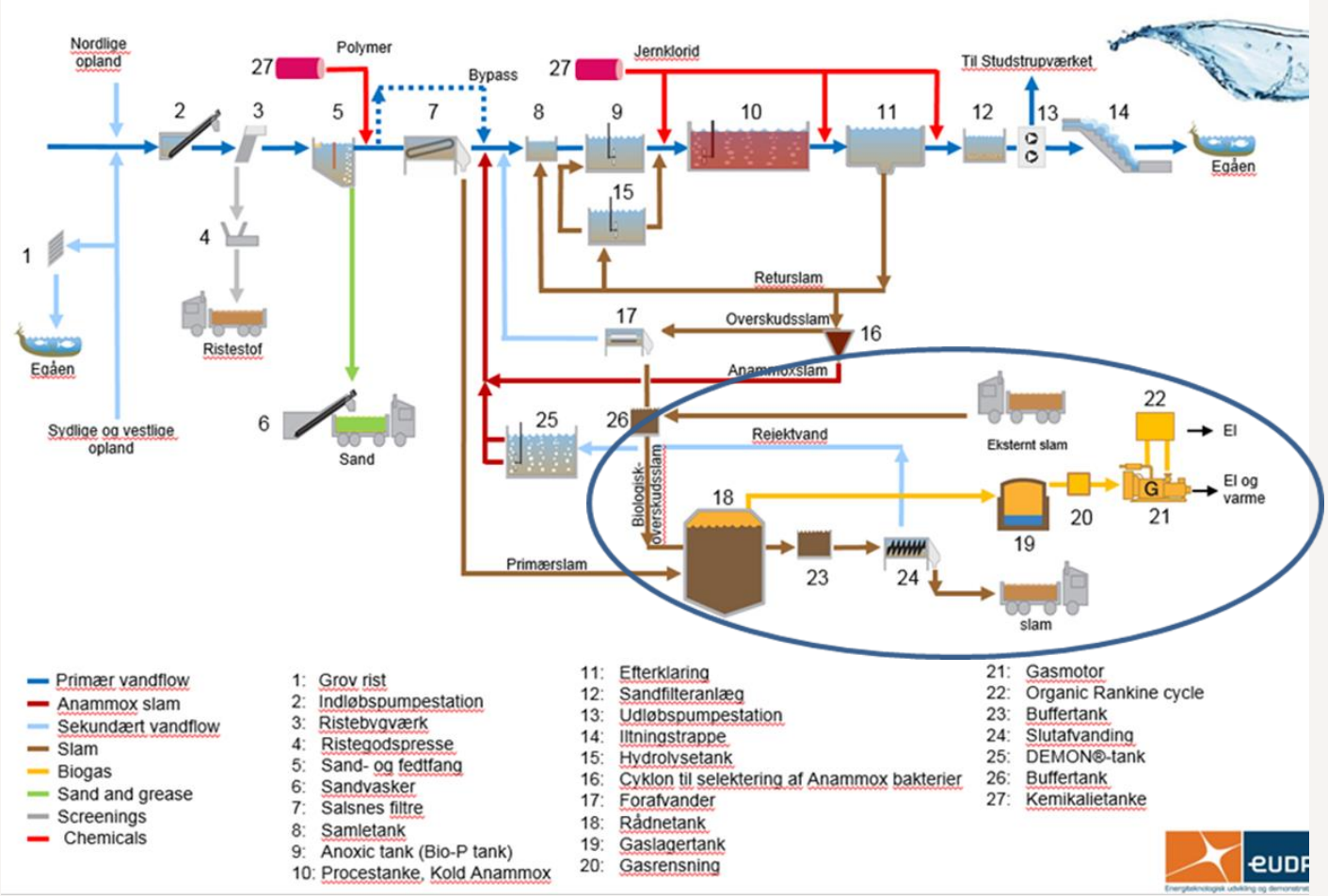


Planned Future Research

- Dolly© (Belach Bioteknik, SE); semi-continuous stirring reactor system to test promising mixtures in long term trials.

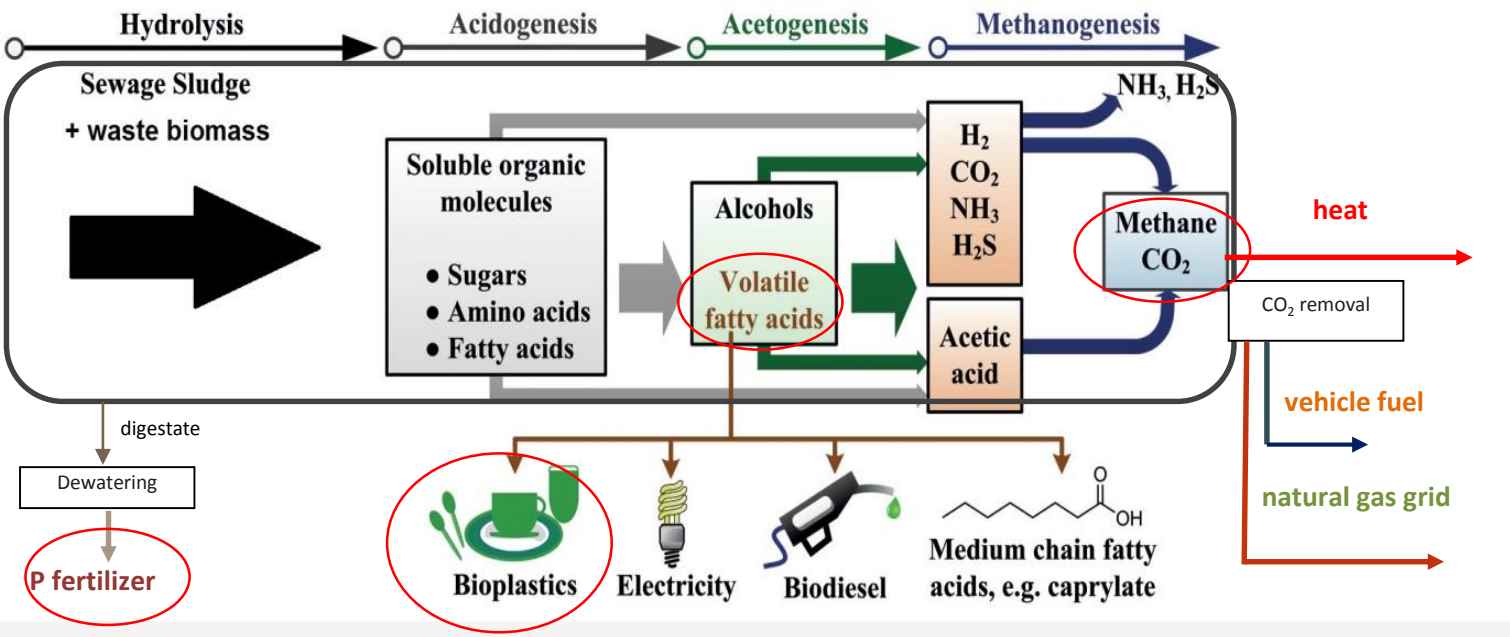


Wastewater and Organic Waste Treatment Facilities – Net Green Energy, Nutrients and Bio-products Producers (RESERVE1, 2017-2019)



The most energy-effective processes and equipment for wastewater treatment and sludge handling as suggested by Aarhus Vand (Presented by Louis Landgren fra Aarhus Vand in a EUDP (Energiteknologisk Utvikling og Demonstrasjon) meeting in Malmø 30-09-2015.

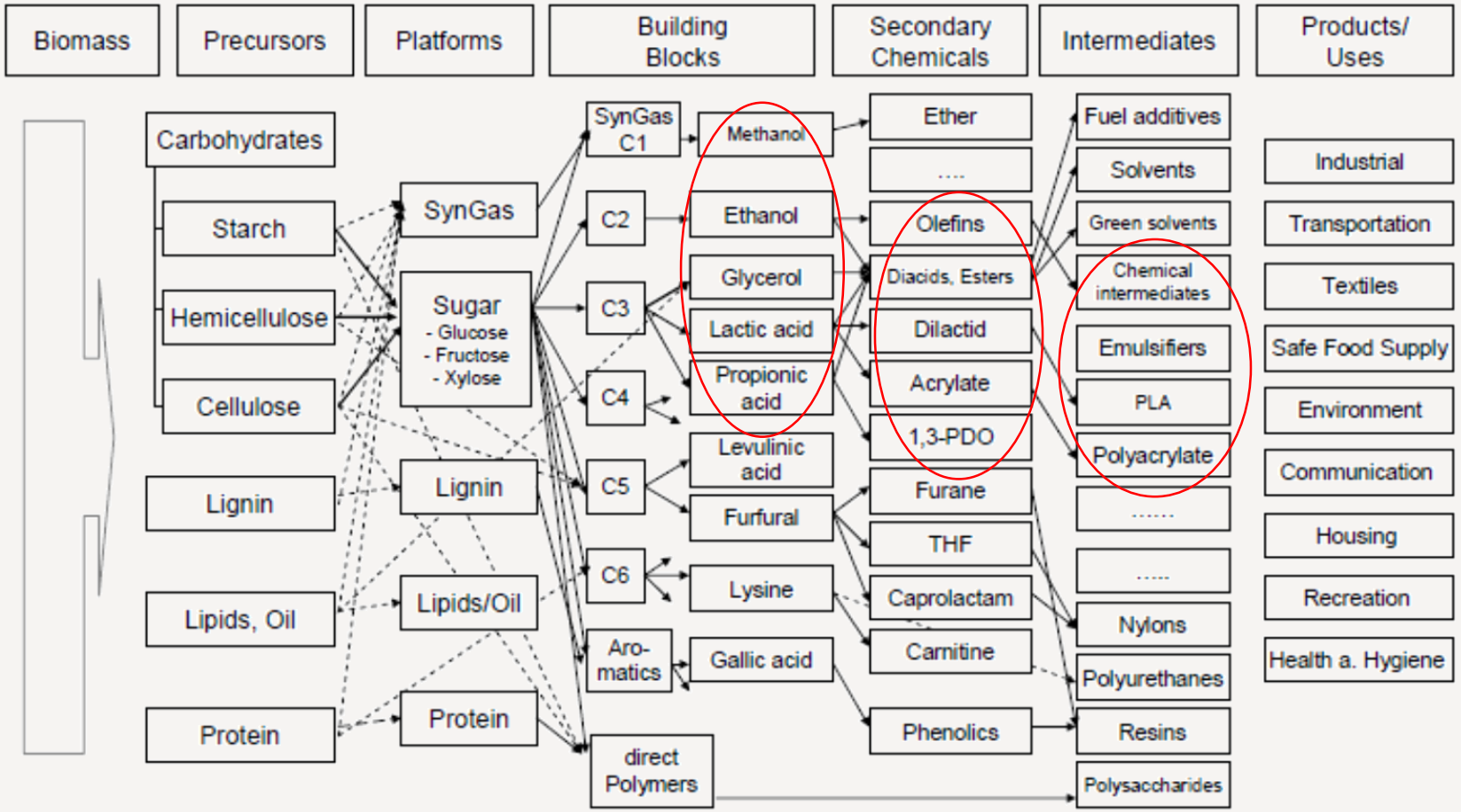
Concept of COWIfonden project



Main goals

- Production of VFA and its up-concentration for further conversion into different bio-products;
- Production of valuable digestate and P recovery.

Concept



Kamm, B. et al. (2006) Biorefineries, Industrial Processes and Products, Wiley-VCH.

Deicers – synthesis from non-fossil carbon source

- Oslo Lufthavn is applying formate based de-icing fluids on all Norwegian airports.
- Main goal of OSL - "0" GHG emission

- potassium acetate
- propylene glycol-based fluids ethylene glycol-based fluids
- sodium acetate
- sodium or potassium formate

Bioplastics from biomass, examples:

Polyacrilate plastic beads

PLA filaments for 3D printing

Thank you for your attention !