Organic Waste treatment in Northern Norway

- a need for higher value products

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«Picture of my life»:

This is a picture of a kiwi, a flightless bird endemic to New Zealand, with a few peculiar characteristics.

The relevance to me is that I am originally from New Zealand.

- Moved to Norway in 1998, and
  - Northern Norway in 2005.
- (Northern Research Institute Narvik A.S., Narvik)

A link to this presentation is that it aims to highlight differences between Northern and Southern Norway with regards to organic waste handling.

Photo: NZ Department of Conservation

Northern Norway's challenges

1. Sparsely populated area
   a. 10% of population of Norway (480 000); 35% of area
   b. Population density 4,3/km² versus 16/km² for Norway

2. Long and narrow – short distance from sea to mountains.
   a. Narvik is 1000 km from Kirkenes and 700 km from the border to Trøndelag.
   b. Large transport distances to gather sufficient waste

1. Cold climate – winters are dark and cold, though coastal climate reduces extremes.
   a. Biological processes need adequate temperatures – problems with composting

2. Less agricultural land requiring fertiliser, compared with Southern Norway

3. But also some advantages – surplus of hydroelectric power in Nordand

Treatment of organic waste

From 2009 landfilling of organic waste was banned.

Incineration is allowed if heat is utilised

Production of biogas has received more attention recently

Anaerobic fermentation to produce biogas

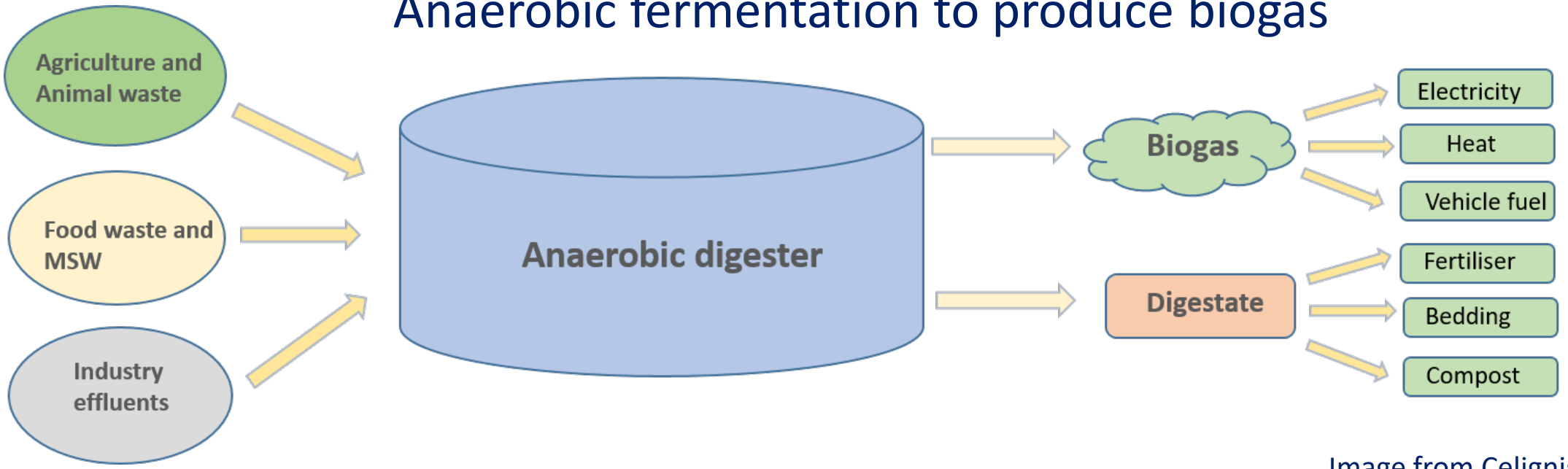


Image from Celignis

How to achieve profitable biogas from organic waste?

1. Economy of scale – large capacity - reduce fixed costs
   a. Rule of thumb: require a population base of 300 000 within 50 km

2. Reduce treatment time – through effectivisation of anaerobic digester
   a. Many different concepts have been proposed, with varying success.

3. Reduce capital costs by reducing the size of the facility
   a. Increase the concentration in the tank – 'dry' fermentation (30 % DM vs <8% DM)

4. Reduce operating costs - reduce maintenance and unplanned stops

5. Realise higher value products from the waste.
   a. Utilisation of the bioresidue is important (fertiliser/soil conditioner)
   b. Biogas needs to be clearned and compressed for storage and use for transport

How has Southern Norway managed to make biogas from organic waste?

1. Economy of scale – there is more organic waste available.

2. Standard process solutions with wet fermentation, low dry matter content (3-6%)
   - 1-tank solution (hydrolysis/acidogenesis/metanogenesis in the same tank)

3. The key to the process economics in Østlandet
   - Bioresidue used as a liquid fertiliser on farms within 50 km of the plant
   - The analysis calculates a future 'income' of avoided CO2 emissions for mineral fertiliser replaced by the bioresidue fertiliser,
     - CO2 emissions valued at 500 NOK/t $_{CO2\text{-}eq}$ – this contributes more than the biogas sales.
   - Politics around future CO2 emission taxes are highly uncertain.

- The solution is not well-suited to Northern Norway.

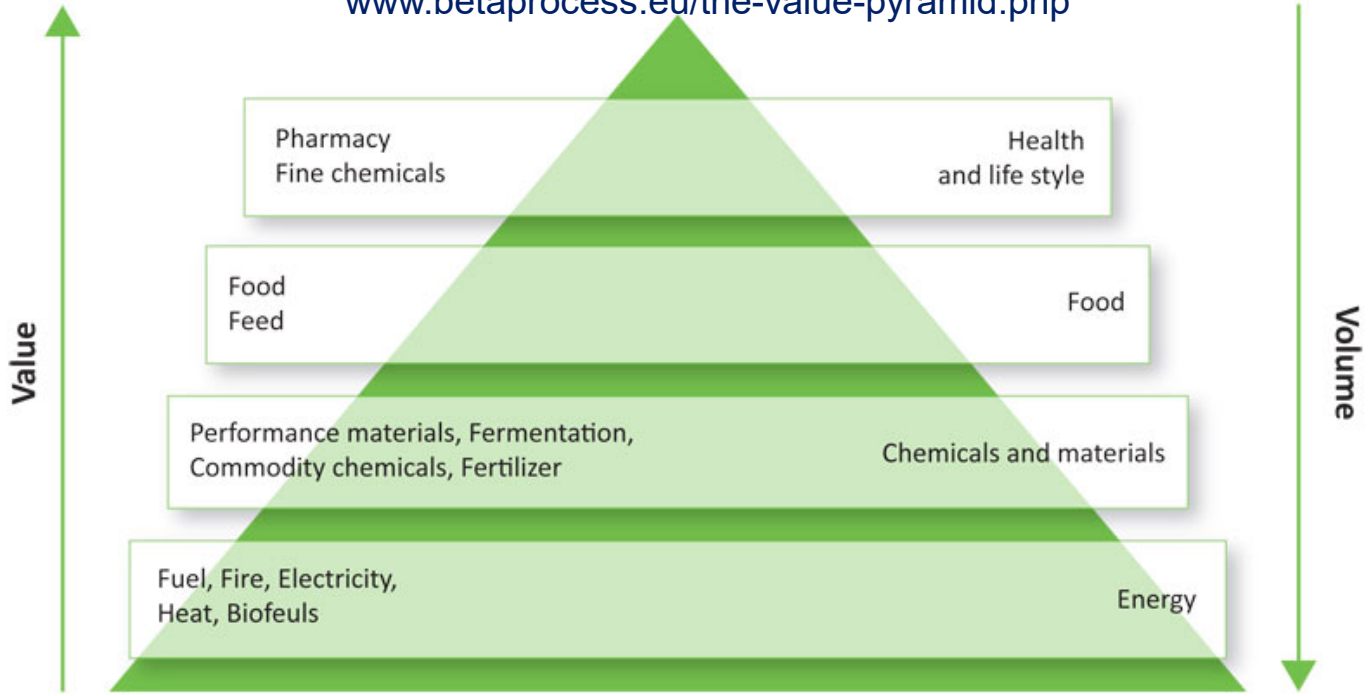
Organic waste treatment in the Narvik region

1. Need a small scale solution (ca 5000 tpy) with the possibilty for expansion if secure supply agreements can be achieved.
2. Have ruled out standard wet anaerobic fermentation
   a. Problems/costs handling dilute bioresidue; and heating of the volume.
   b. Lack of nearby farms with fertiliser needs
   c. Larger plant due to low dry matter
3. Evaluating dry fermentation
   a. Many commercial processes available, but problems have been experienced in Norway
   b. Finland is seen to have key competence in this area
4. Evaluate alternative products - biorefining
   a. Composted bioresidue sold as solid fertiliser/garden soil.
   b. Possibility for other value streams such as ethanol, lactic acid,
   c. What product prices need to be achieved to achieve economical operation?
   d. Distributed production? – transport of precursors to central purification?.

Value creation

Higher value products
- tend to have smaller volume markets.
- May require more expensive processing.

www.betaprocess.eu/the-value-pyramid.php



Approx value for different uses of organic waste

	Value ($/t biomass)
Bulk chemicals	1000
Transportation	200-400
Animal feed	70-200
Electricity	60-150
Landfilling	Minus 400

Tuck et al 2012 Science vol 337; p695-699.

Bio-based chemicals analysis by the EU BIC consortium

The Bio-based Industry consortium has chosen to not fund projects that are primarily developing energy carrier products (eg biogas)

Transport fuel could be sold for about 0,4€/kg, but if used internally the cost saving of avoiding fuel pump price could be 1,5 €/kg

After 10 years of BIC projects the bio-based products are still at pricess that require large scale facilities.

However within the average prices for the categories there are some products with higher prices.

Approximate price and turnover figures for bio-based products categories

Product category	Price (EUR/kg)	Turnover (EUR million/a)
Platform chemicals	1.48	268
Solvents	1.01	76
Polymers for plastics	2.98	799
Paints, coatings, inks and dyes	1.62	1,623
Surfactants	1.65	2,475
Cosmetics and personal care products	2.07	1,155
Adhesives	1.65	391
Lubricants	2.33	552
Plasticisers	3.60	241
Man-made fibres	2.65	1,590
Total	1.94	9,167

Spekreijse et al 2019 JRC bio-based chemicals market report
http://publications.jrc.ec.europa.eu/repository/handle/JRC112989

Biorefining of organic waste

- Biogas is a C1 process – breaks down complex componds to the simplest form
  - This makes it difficult to produce larger molecules of higher value products
  - Therefore focus on extracting chemicals that retain the complexity of the raw material (eg hydromethylfurfural (HMF) and other «biobased platform chemicals»
  - Transport platform chemicals to central processing

- Dry fermentation opens for more flexible processing than wet fermentation.
    - Contact between fluid and solid phase achieved by circulation of a permeate.
    - Permeate can be separated or treated to extract by-products
    - Larger capacity per tank volume, less fluid to hold warm.
  - Sequential Saccharification and Fermentation
    - Use enzymes sequentially to separate out certain fractions
    - E.g. first separate out sugars, then proteins/amino acids and then fatty acids.
    - Remainder can go to production of biogas and soil improvement
- Local processing to extract precursor chemicals, sent to centralised purification
  - Bioresidue used locally - avoid transport of bulk of waste.

Conclusion

- At present do not have a clear plan for realisation of organic waste valorisation.
- Municipalities in Northern Norway have used 10 years on evaluation of wet fermentation for biogas and concluded it is not economical for Northern Norwegian conditions.
- ‘Dry’ fermentation for biogas could be combined later with extraction of bio-based chemicals

- Interested in discussing concepts with other companies in Northern Calotte region.