“Aquatic biomass for biogas plants - Realistic feedstock source or an academic idea - incl. full scale experiences from Solrød biogas plant”

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Presentation outline

Problem area
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Conclusions - Lessons learned from Solrød?

Problem area

- New centralized biogas plants are being established in Denmark after almost 10-12 years of stagnation.
- Important to disseminate this tech. with as many environmental & societal benefits as possible, thus
- Identify how new biogas plants can be implemented learning from a successful case plants utilizing various types of feedstock, here with
- Special emphasis on blue biomass from the aquatics, and on
- The case of Solrød Biogas Plant using cast seaweed from the Bay of Køge.
- What can we learn from Solrød as far as utilizing seaweed for biogas?

Macro algae's BGP & types

Previous mono-digestion experiments:

1) Hansen (1982):

- Experiments with various macro algae spices native to Scandinavia were digested.
- Batch experiments in mesophilic temperature.
- Completed after 12-15 days.
- BGP result: 350-480 ml CH_4 g VS-1

2) Nkema & Murto (2010)

- Experiments with unspecified cast seaweed in southern Sweden.
- BGP result: 120 ml CH_4 g VS-1

3 types of macro-algae or seaweed (total of 10,000 species):

- Brown seaweed e.g.: Saccharina latissima; Fucus serratus; Ascophylum nodosum.
- Red seaweed e.g.: Gracilaria verrucosa; Palmaria palmate; Asparagopsis armata.
- Green seaweed e.g.: Codium tomentosum; Ulve lactuca.

Green seaweed - Zostera maritima

Red seaweed – Palmaria palmate

Brown seaweed – Saccharina latissima

Case area introduction

Location of Køge Bay

Citizens are challenged by the cast seaweed

- Cast seaweed creates problems for citizens in Køge area due to smell from decay.
- Hamper recreational opportunities in the area.
- Pose cleaning expenses on Homeowner Associations along the beach & on Solrød Municipality (thus tax payers).

Optimist ☺

At Køge Bay the cast seaweed is composed by:

Main part is Ålegræs/eelgrass (Zostera maritima) = green seaweed:

- Flower plant growing at the sea bottom.
- Washed up on the beach during late summer and fall.

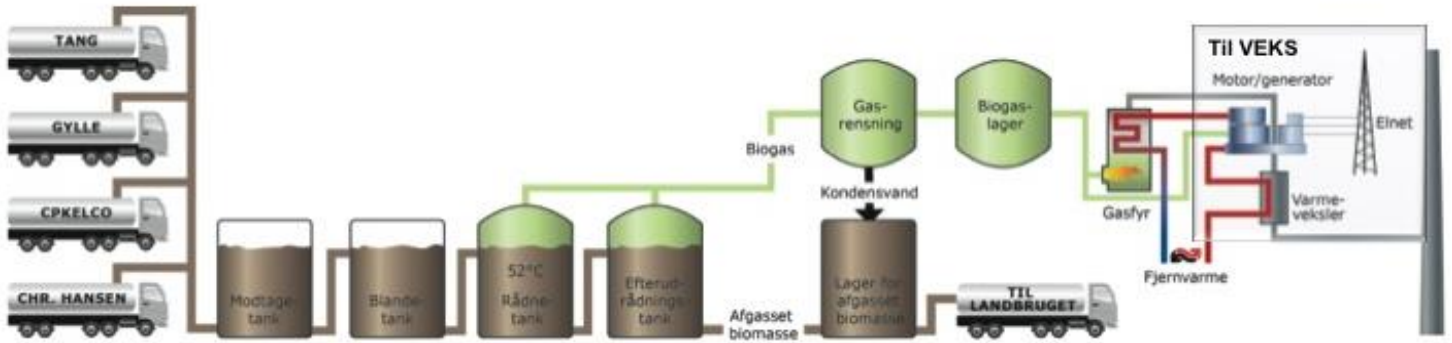
Minor part is Dun-alger (Ectocarpus) & Vat-alger (Pilayella littoralis) = brown seaweed:

- Grow in the sea on rocks, stones and on other algae's.
- Present first and last in the season respectively (also called ‘fedtemøg’).

Total seaweed potential from Køge Bay:

- 42,000 tons available annually for biogas production.
- The amount of cast seaweed varies during the year, and between years, with
- Lower amount of seaweed available during winter.
- 60-90 % of the seaweed measured by weight is sand, the remaining organic materials.
- Require cleaning/washing before utilized for biogas production.

Solrød biogas plant



Feedstock:

- Only 25 % manure & 75 % other types of feedstock (normally opposite).

Cast seaweed from the Bay of Køge	= 7,400 tons
Manure from local cattle and pig farmers	= 41,500 tons
Pectin waste CP Kelko (starch)	= 79,400 tons
Ferment. waste Chr. Hansen (enzymes)	= 60,000 tons
Total amount	*= 188,300 tons/year*

Process:

- Feedstock mixed in Mixing tank before pumped to the Reactor tanks where heated.
- 2*8,000 m3 reactor tanks fully stirred.
- Mesophilic process temperature applied in reactor tanks.
- The biogas is cleaned for SO2 before storage.

Energy output:

- 6 mil. m3 biogas (methane, CH4) produced annually.
- Biogas converted in a motor/generator for power and heat generation (CHP).
- 23 GWh/year electricity & 28 GWh/year heat (district heating, DH).
- DH send to citizens in Solrød Municipality substituting fossil fuel energy (previously based on individual oil or Ngas boilers).
- Solrød Municipality now avoids 26,000 tons of CO2 emissions annually from energy usage.
- From energy *and* methane reductions of 43.700 tons of CO2 equivalents are obtained.

Digestate:

- Transported by trucks to farmers in the local area.
- 80.000 tons digestate used at one farm as fertilizer, and the remaining by smaller farms.
- This digestate substitute the use of artificial fertilizer.



Benefits & challenges

Utilization of seaweed v. other feedstock:

Biomass	Amount(t)	Share of biogas	Contribution
Cast seaweed	7,400	0.5 %	Nutrients & water quality
Manure	41,500	9.5 %	Gas & process stability
Pectin waste CP Kelko	79,400	75,00 %	Gas
Fermentation waste Chr. Hansen	60,000	15,00 %	Gas & nutrients

- The use of seaweed is only a small share of the total feedstock, and provide
- Relative high content of nitrogen in the digestate (4 kgN per tons digestate).
- Doesn't hamper the total gas yield from feedstock mix in any amount (≈CH4 pct. = 54-55%), but
- No real contribution to biogas production & Only 25-30 % actually converted to gas:

Biomass	Dry matter TS %	m3 CH4/tons TS
Cast seaweed	58.80 (a lot of sand)	21.50
Pig manure	6.80	370.00
Cattle manure	9.30	260.00
Horse manure	48.00	400.00
Pectin waste CP Kelko	16.00	409.40
Fermentation waste Chr. Hansen	23.40	71.60

Seaweed collection and pre-treatment:

- The cast seaweed is collected from the beach by a Dumper with harrow, and
- Dumped back into the sea water at the beachfront.
- Washed in the sea water using a Trencher (rendegraver) with grill-shovel (risteskovl).
- The washed seaweed is loaded on the Dumper and transporting to the biogas plant.
- Before the seaweed was collected, piled up on the beach and de-watered for 2 days.
- Seaweed consists of appx. 35 TS % when arriving at the biogas plant.
- Washed again in a tank with a bottom cyclone it consists of 18-20 TS % appx.
- Seaweed chopped in a macerator before mixed with other feedstock, and
- Feed to the biogas reactor tanks.

Challenges:

- Seaweed odor problems when it arrives to the plant, thus
- Several techniques will be tested to avoid odor complaints.
- Emptying the cyclone for sand & Short lifetime of macerator.

Grill-shovel

Dumper with harrow / tear collects cast seaweed

Trencher with grill-shovel wash seaweed

Environment:

- Collecting and digesting the seaweed helps:

- Avoid 62 tons of nitrogen & 9 tons of phosphor leakages to the Køge Bay annually.
- Comply with Municipal targets in the Water Framework Directive (WFD), and
- Avoid costal eutrophication of the Køge Bay river basin.
- Avoid decay of seaweed on the beach emitting 570 tons methane, equal to 11,900 tons CO2 equivalents per year.
- But content of cadmium in seaweed samples collected during winter (< 0.8 mg/kg), that
- Prohibit the use of seaweed applied as fertilizer during the months of October to April.
- May to September lower cadmium content (lower sedimentation and uptake in plants)

Economic benefits:

- The treatment of problematic seaweed in the biogas plant reduce waste management costs with 1/10 the price, as
- Seaweed used to be plowed-down on the beach, or
- Transported to other municipalities for different means of usage & disposal/incineration.

New services:

- Re-cycle a high nutrient biomass resource previously regarded as problematic waste, or
- Used inefficiently as animal feed with long transportation as a consequence.
- Provide an easy-to-distribute fertilizer when delivered to farmers, with
- High content of nitrogen highly accessible for farm crops.

Conclusions
- Lessons learned from Solrød?

Why use seaweed in biogas plants?:

Cons':

- There is not a lot of gas in seaweed, but is doesn't hamper the gas production.
- It's a difficult feedstock (collection, cleaning for sand, seasonal supply, etc.).
- Contain heavy metals which prohibit use during winter season, thus
- Ensilage of summer seaweed an option, but requiring handling, storage & knowledge (smell).

Pros':

- Gate fee for treating seaweed from local community could benefit the biogas plant economy.
- (Solrød can treat seaweed amounting to 40,000 t/y, now only using 7,400 t/y).
- Easy-to-distribute digestate with high nitrogen (N) content.
- CH4 from seaweed decay on the beach can be avoided, and
- Leakages of nitrogen & phosphorus to water basin's reduced.
- Cast seaweed can be the 'driver' for municipalities, farmers & other actors to support biogas!
- Large potentials in Denmark for applying biogas solutions involving cat seaweed;
- E.g. Stevns & Guldborgsund Munitipalities would like to transport seaweed to Solrød, but
- Now also consider to implement their own biogas plants to treat cast seaweed.

Thank you