Biomass as Energy Source in Greenland - Constraints and Potentials

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Abstract
The Arctic region needs to explore alternative renewable energy in order to deal responsively in relation to the external obligations in the shape of the Kyoto agreement. Biomass is one of a variety of local renewable energy sources in the Arctic. Compared to many other renewable energy sources, biomass has been poorly mapped so far. Based on an analysis of the potential of the natural resource potentials, the technology potentials and the economical potentials of biomass (bio-gas from fishery waste), are presented. Furthermore, this article tries to set focus on the huge and various local potentials for biomass in Greenland.

Resumé
Der er et stort behov for at undersøge forskellige vedvarende energikilder i Arktisk og Grønland for at nå miljømålene. De steder hvor storskala vandkraft ikke forventes at erstatte fossile energikilder indenfor 10-20 år, er det hensigtsmæssigt, at vurdere de lokale potentialer for biomasse. I denne artikel fremlægges en kort oversigt over biomassens anvendelse i Grønland pt. ligesom resultaterne af en undersøgelse af de ressourcemæssige, teknologiske og økonomiske potentialer af biogas fra fiskeriaffald i Royal Greenland A/S i Sisimiut bliver præsenteret.

1. Framework
The key to successful adaptation of sustainable energy planning is appropriate regional governance. The Arctic region need to explore alternative renewable energy in order to deal responsively with the unavoidable contact between the center and the periphery and with the fact that it is getting increasingly difficult to reach the external obligations in the shape of the Greenlandic Home Rules ratification of the Kyoto agreement. Biomass is one of a variety of local renewable energy sources in the arctic that need to be investigated. In a Greenlandic context, biomass is not mentioned in the energy planning before 1994 and according to the Greenlandic energy plan bio-mass is not expected to be important within the next years. Biomass for energy use has a huge potential in the arctic regions. Nevertheless these potentials are poorly investigated – except waste from household used for district heating.

2. Task
In order to discover and measure the potentials of biomass in Greenland and its potentials in relation to the ongoing task of transform the Greenlandic energy systems towards a system more or less based on renewable energy, we need to map

the local natural potentials in relation to the development of the technical potentials and the development of the economical potentials.

Biomass can be divided in tree types;

- Solid (organic waste material),
- Fluid (bio-oil),
- Gas (bio-gas).

'Waste' from a production is often considered to be unuseful. 'Waste' from one production may be suited as a 'resource' in other productions or in a line of productions. This way of considering waste, is used in this investigation.

3. Potentials

Solid biomass is relatively well discovered. In the 1990' the Home Rule Government, The Danish Environmental Authorities and students from Roskilde University, mapped the local natural and technical potentials in some towns. I the 1990' and the 2000' some waste burning plants was build in the 6 largest towns. The produces head is used as a supplement to the district heating grid.

Fluid biomass is implemented in the mid 1990, in Royal Greenland A/S in Ilulissat. The plant has developed a method to extract bio-oil from waste material from the production of Greenlandic Halibut. This plant produces oil, in an amount, that can cover the factory need of heating. Besides this example the use of bio-oil does not exist. The potentials are interesting to discover and the sources of bio-oil is existing wherever fishing or hunting based industry is situated. In these areas, the potentials of bio-oil need to be mapped and measured.

In relation to this, the newest investigations in this field are the huge potentials that exist of the Seaweed harvested along the costal line in the arctic. In Norway, Scotland and in the southern part of Greenland it is harvested in order to produce medicine. The 'waste material' from this production may be used as a 'resource' in other productions or a line of production. The waste from producing medicine may be de-gassed before it is used as manure in the farming industry. Otherwise the waste may be fermented in order to produce bio-ethanol. The natural potentials of this have been proposed to be huge and may produce bio-ethanol in an amount that it may contribute to need for bio-ethanol in the fishing and transport sector in Greenland.

Bio-gas is not yet implemented in Greenland. The only investigation of the natural, technical and economical potentials is made by Palvig, 2005, from the waste material from shrimp and crab production in Royal Greenland A/S in Sisimiut. The investigation is the result of a master thesis at Roskilde University and consultant report for the Greenlandic firm, Royal Greenland A/S.

The results of this investigation are disclosed later on in this article. The production data is undisclosed, due to an agreement with the firm and the author. The results have been discussed and accepted by representatives from Royal Greenland A/S, The Danish Energy Authority, The Danish Environmental Authority and two research institutes in Denmark ('Nordvestjysk folkecenter for vedvarende energi', 'EnergiPlan' and Roskilde University).

The results are sensational in the way that they show that the natural, technological and economical potentials are very large and relevant to explore even though the assumptions are very conservative.

If the potential is used, the factory can be self-sufficient with heat. The sources of bio-gas are many and not yet mapped in Greenland. Waste from fishery, incl. Seaweed and hunting are obvious.

Potentials for bio-gas in Sisimiut
An investigation of the natural-, technological- and economical short and long tern potentials of bio-gas, from waste material from the production of shrimps and crabs in Royal Greenland A/S in Sisimiut, Greenland.

Even based on the most conservative assumptions, the investigation shows, that there exist at huge natural, technological and economical potential for biomass in relation with the factory.

4. Resource potentials

4.1 The amount of waste

First the natural potential was recognized. On the basis of ‘Green accountings in the energy field’, the fluctuating use of raw material, energy and waste material within the factory was mapped. The result is that there is a huge potential for producing bio-gas from the waste accumulated from the crab and shrimp waste production.

The amount of waste from the production of shrimps and crabs varies around the year – without to long periods (14 days) without ongoing waste supply. The amount of waste is relatively large.

The total amount of waste from shrimps was 6.501.734 kg/year with an average of 125.033 kg/week. The total amount of waste from crabs was 341.685kg/year with an average of 6.571 kg/week. The total amount of waste was 6.843.419 kg/year with an average of 131.604 kg/week.

4.2 From waste to bio-gas

It is possible to enlarge the amount of gas production with technical addition. Without this, the gas production from shrimps varies between 0-4.114 Nm^3/week. With the average production of waste, the expected production of gas is 1.407 Nm^3/week and 73.145 Nm^3/year.

It is possible to enlarge the amount of gas production with technical addition. Without this, the gas production from crabs varies between 1,5 – 6,6 Nm^3/week. With the average production of waste, the expected production of gas is 3,7 Nm^3/week and 192 Nm^3/year.

With technical addition, the expected amount of produces gas is increased with 25%.

5. Technological potentials

The technological potential is based on two parts: the biological aspects and the technology of the biogas plant.

5.1 The biological aspects

The biochemical processes are:

Faze 1: Hydrolyze, bacteria produces glucose etc.
Faze 2: Acid producing bacteria produces alcohol, acid, H_2, CO_2 etc.
Faze 3: Methane, bacteria produces methane (survive 5-70 C, best results 30-40 C)

The biogas consists of:
55-65% CH_4 (methane)
35-45% CO_2
0-½ H_2S

The methane is used for energy purposes. Either to produce heat or heat+electricity.

1 Nm^3 is equal to approximately 0.6 L oil or 6 kWh. The amount of energy that is gained depends of the used technology.

If the engine produces heat and electricity, 60% of the energy will be used as energy compared to 55% if the engine only produces heat.

If the plant is endorsed, it will reduce the use of oil in the city of Sisimiut with approximately 2%.

6. The technological potentials

Best practice in Denmark shows 4 types of plants. The 'Opretstående smedemesteranlæg', consist of 'reaktortank', 'efter-reaktortank', 'overdækket stort gaslager', 'mercerator-findeler', 'snegleomrører', konisk bund, ekstra isolering, '124 kW Stirling motor med varmeakkumuleringstank'. This is the best practice of the generation one plant (with arctic modifications) for this purpose. See Palvig, 2005, page 19-20.

7. Economical potentials

The measurement of the cost/benefit in this plant includes both establishing the plant and maintenance.

7.1 Establishing

'Opretstående smedemesteranlæg' additions. Fabrication: BioEnergy Lab, Dansk Alu-stål A/S.
'Roof on the gas storage tank'; (10% larger amount of gas)
Circulation device; Fabrication: 'Filskov biogasfællesanlæg'
Mercerator (cutter)
124 kW Stirling engine and larger gas storage and heating accumulation tank.
Extra (arctic) isolation.
Transportation from Denmark to Greenland (Sisimiut).
Building the plant in situ.

This includes both production of renewable energy instead of fossile energy and saved expenses.

7.2 Production of energy:

Production of heat

	Produced gas (both crab and shrimp)	Produced kWh/year Effect 35%, 2,13kWh/m^3 gas	Economic value of heat production (0,33 Dkr/kWh)
Nm^3 gas without additions	73.337 Nm^3/year	156.061 kWh/year	51.500Dkr/year
Nm^3 with additions (+25% gas production)	91.671 Nm^3/year	195.075 kWh/year	64.375 Dkr/year

Production of heat and electricity

	Produced gas (both crab and shrimp)	Produced kWh/year Motor/generator - effect 1,84 kWh/Nm^3 gas	Economic value of heat production (0,33 Dkr/kWh)
Nm^3 gas without additions	73.337 Nm^3/year	134.940 kWh/year	197.012 Dkr/year
Nm^3 with additions (+25% gas production)	91.671 Nm^3/year	168.674 kWh/year	246.265 Dkr/year

Furthermore the value of sale of manure is not measured in these calculations. This may make the brake/even balance better. Production of fodder for fish costs the firm approximately Dkr. 100.000,-/year. This is included as an income in this calculation.

This means that the brake/even point is approximately 7-9 years and the technical period is op to 20 years.

8. Constraints

The economical potentials is interesting, but it is a constrain that the common research in this field is lacking and not endorsed from the energy planner. Such results could provide the needed information (research in technology – biological and technical – and the arctic modifications) that will make it easier for the stakeholders to think of bio-mass as an energy source and become an active partner in the effort of reaching the environmental objectives.

Furthermore the economical potentials would be larger if is legal for a producer of energy based on renewable energy to produce both heating and electricity as well.

9. Perspectives

The faster we can map the local sources and potentials of the different types of biomass, the faster and better planners, politicians and researchers will discover the unused potentials for biomass. The yet not fully discovered potentials of Seaweed for medicine, energy and natural fertilizer is an obvious task for collaboration around the Vest Nordic countries.

If Greenland is focusing on developing an arctic knowledge about different types of biomass I Greenland's sub artic and arctic regions, it would be an potential huge niche for export of know-how, f.e. to the other Arctic parts of the world, which is seeking after renewable energi solutions in the arctic all ready.

The Danish energy authority expects an ongoing decrease in the price of the plant and an ongoing increase in the price of oil. In the last 7 years the price of oil in Greenland has increased – especially the last year. Therefore it is very interesting to update this investigation – also when ‘biomass plant generation 2’ is finished. The Fishing industry, the local stakeholders, the energy planners, ARTEK and others may become more interesting regarding biomass as an alternative along with to the other renewable energy sources, if the sources and potentials are mapped more structural.

10. Literature

Andersen, 1999, I: Møller & Lybæk, 1999, E.L.Andersen. Interview.

Berthelsen, 1999, L. Berthelsen, Fabrikschef, RG A/S Sisimiut, 1999.

Berthelsen, 2000, L. Berthelsen, Fabrikschef, RG A/S Sisimiut, 2000.

Berthelsen, 2003, L. Berthelsen, Fabrikschef, RG A/S Sisimiut, 2003.

Brodersen, 2000; Katja. Brosersen, “Indhold af skaldele fra rejer”, Royal Greenland A/S, Nuuk, 2000.

Carl Bro A/S, 1998, ”Hovedrapport om affaldsforbrænding undersøgelser i Sisimiut”.

Energiplanudvalget, 1995; ”Energiplan 2010” Rapport nr. 1, 2, 3, 4, 5.1, 5.2, 5.3, Nuussuaq, 1995.

Energistyrelsen, 1996, ”Danmarks vedvarende energiressourcer, Danmarks miljøfremtider, Energistyrelsen, Miljø- og Energiministeriet, 1996.”

Grossmann, 2000, Liniemester, Nukissiorfiit, Sisimiut, interview.

Jespersen, 1998, I: Møller&Lybæk, 1999; B.Jespersen, Linkogas, Interview, 18.11.1998, Rødding.

Kjær, 1996; T. Kjær, ”Best practice for strategy and promotion tools in the field of power-from-biomass” in “Green power and promotion of power-from-biomass”, Storstrøoem County, TBM Project, A study of market constraints on the development of power-from biomass, EC TERMIE programme, Action No. STR-1125-96-UK, 1996.

Kjær, 1996; T. Kjær, “Grønt regnskab på energiområdet – eksempler fra Møn Kommune og Storstøms Amt”, 29. august 1996.

Larsen, 1999; B. Larsen, Interview, Chef Nukissiorfiit, Sisimiut.

Lindegaard, 2000; T. Lindegaard, Forsyningschef KNI-Pilersuisoq, energidivisionen, interview.

Mathiesen, 1998 i: Møller &Lybæk, 1999, G.A.Mathiesen, interview 17.1.1998.

N.f.f.v.e, 1996; Nordvestjyst folkecenter for vedvarende energi, unofficial values and biogas yield from various biomass wastes, marts 1996.

Institut for Bioteknologi, u.å.; DTU, I: Mølle&Lybæk, 1999.

Palvig, 2005; ”Potentialer for vedvarende energi i Sisimiut – Undersøgelse af de ressourcemæssige, teknologiske og økonomiske potentiale for reje- og krabbeaffald fra Royal greenland A/S, Sisimiut, masterthesis”.

Palvig, 2005; ”Omstilling til vedvarende energi – Fra Grønlandsk målsætning til plan og gennemførelse”, Master thesis, Roskilde Universitet 2005.

Rasmussen, 2005; Lektor, RUC, Interview.

Ruello, 1976; I: Brodersen, 2000, N.V. Ruello, “Biological characteristics and Australian Prawns, Australian Fisheries, 1976.

Sørensen, 2000; sektionsleder energiafdelingen, Direktoratet for Boliger og Infrastruktur, interview, 2000.