Biomass Supply Chain Mobilization in the North Sea Region

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BIOMASS SUPPLY CHAIN MOBILIZATION IN NSR

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Foreword

A key characteristic of renewable energy is that - in contrast to the conventional power plants and their associated continental grids - renewables are typically a decentralised energy form. Hence targets cannot be implemented by the decision makers in Europe's capitals; the onus is on the regions and regional development initiatives. Transnational cooperation can play a major and cost-effective role in capitalising on the North Sea Region (NSR)'s diversified but largely unaligned renewables expertise, especially in respect of the under-potential deployment of bioenergy resources. This is the assignment adopted by the Enercoast project.

Pre-project consultations conducted in the partner regions took stock of bionenergy potential and the obstacles to sustainable business development needed to deliver the ambitious energy policy targets. Despite divergent business development environments and outstanding technological challenges a common problem was identified: many ambitious, stand-alone entrepreneurial initiatives in the field of bioenergy fail to penetrate the regional energy market due to a lack of business resources, market access and dependable supply chain economics. This generic factor of renewables promotion is a decisive one: skilful management of supply chains, especially when these constitute an innovative challenge to established monopoly structures, is a prerequisite for the success of such ventures. Hence the response to the European renewables agenda shifts from the political arena to the field of business management.

New energy sources can however profit from established business models. The Enercoast strategy is one of applying proven supply chain management methodology and tools to the underdeveloped bioenergy market in a NSR regional context. The project's focus is clearly set on a defined range of regional bioenergy market initiatives and their transformation into sustainable value chains.

Supply Chain Management (SCM) features an integrative approach to dealing with the planning and control of the material flows from suppliers to end–users and focuses on a network of firms interacting to deliver a product or service to the end customer, linking flows from raw material supply to final delivery.

The intention of the report is to describe the status of the selected regional supply chains at the start of the project and try to answer the questions

- What key indicators for supply chain performance have been selected?
- Who are the key stakeholders identified in the supply chain analyses?
- What gaps in the existing or projected supply chains have been identified?
- What are the targets set for the regional supply chain projects, i.e. what is the planned focus of the project intervention?

The present report is the completion of project phase 3 Supply chain mobilization, which takes off from the performance analysis of the investigated supply chains, their deficits and a structured evaluation of potential options. The performance assessment in turn will feed into the remaining project phases and the promotion of locally defined business optimization strategies in each region.

Background

The EU's policy on renewable energy is summarized by the 20/20/20 target (20% renewable energy, 20% greenhouse gas reduction and 20% reduction in energy consumption by year 2020) and documented in the Renewable Energy Directive (RED 2009/28/EC) that will have to be transposed into national law by December 2010. The Directive makes it compulsory for Member States to adopt their own National Renewable Energy Action Plans (NREAPs) by June 2010. The RED directive specifically applies sustainability criteria to biofuels.

NREAPs include specification of detailed targets for the RE share of the energy consumption in 2020, as well as trajectories and described measures with estimated effects. The progress achieved in the implementation of the NREAPs is to be evaluated in reports to the Commission each second year.

In 2007 the EU as a whole had a 7.8% share of renewables in its primary energy consumption according EEA[1] , ranging from 0% in Malta to 30.9% in Sweden, meaning, that reaching 20% renewables by 2020 is an ambitious target, which will require substantial effort, if it is to be met. Notably, slightly more than 2/3 of the renewable energy comes from biomass-based renewables and this share is predicted for 2020. This figure contrasts sharply with the large focus on wind, solar, geothermic, wave and other types of renewable in policies and media.

The present state of RE and the relative target for 2020 in the individual Member States is rather different: The Danish Government has set the political objective of reaching 30% renewable energy by 2020 and furthermore launched a Green Growth Plan, which sets out the goal of utilising more perennial energy crops and at least 50% of all livestock manures treated for energy purposes.

The bioenergy sector in the EU needs to undergo major development in order to reach the policy goals and fulfil the legal requirements in force. Heavy investments in biomass production and energy conversion are needed and associated businesses in regional authorities, institutions and companies dealing with planning, research, logistics, advice and other will have to gear up to assist the development.

The EU's Biomass Action Plan is one of the important strategy papers that define the challenges and opportunities for the use of biomass including, for instance, using more waste as a biomass resource for bioenergy production. The trade with biomass and the market for biomass in general require a certain level of standardisation in order to obtain consumer confidence and The Action Plan explicitly stipulates that supply chains from biomass to bioenergy need to be optimised.

The Enercoast approach is to explore the potential of meeting the said political targets from the local stakeholder perspective, i.e. the municipalities and other public and private actors influencing the development of business models for farmers, foresters and other bioenergy producers.

1. European Environment Agency - http://www.eea.europa.eu/data-and-maps/figures/share-of-renewable-energy-in

The strategy is clearly a bottom-up approach to delivering the declared goals in a transnational context.

SUSTAINABLE BIOENERGY SUPPLY MANAGEMENT

The business model agreed on as basis by all Enercoast partners is the Sustainable Supply Chain Management (SSCM) model developed at the Department of Ecological Economics at the University of Oldenburg[2] and merged within the project with a process management approach based on the EFQM[3] model.

For bioenergy to succeed, a comprehensive approach to complete supply chains is needed to safeguard the business initiatives and defined stakeholder interests, e.g. those of energy farmers, foresters and other stakeholders involved. The SSCM solution features a 3-tier focus and applies performance criteria to each stage of the bioenergy supply chain from the materials, the economic stakeholder and the social-cultural perspectives.

Insert simple graphic to illustrate a supply chain

Sustainable supply chain analysis has four key challenges, adapted from Franck (2008).

1. Ecological challenge: customers are sensitive to environmental violation and e.g. energy waste and recycling of nutrient should be taken into account

2. Social challenge: Well organised supply chains are socially acceptable to providers, neighbours, Municipalities, end consumers and NGO's

3. Economic challenge: secure and stable supply of quality biomasses at competitive prices and stable frame conditions for investments and turn bioenergy into a sustainable business

4. Integration Challenge: Integration of the above aspects – true sustainability

One could argue that if bioenergy cannot be proven more sustainable than other alternatives (including fossil fuels, wind, solar energy etc) it should not be promoted. We believe that bioenergy has some unique advantages especially in terms of environmental impact (GHG emissions, nutrient leaching etc), but in some cases the social and economic sustainability has yet to be proven. In line with the project's process management emphasis this report analyses the sustainability aspects of each supply chain though identification of indicators, gaps, enablers, and options in each regional context.

Providers of bio-energy should be able to document to shareholders, customers and the public society that all links in the supply chain comply with the basic principles of sustainable development. In the following we present a series of SSCM analyses conducted in the participating regions and pinpoint where Enercoast project intervention could improve business opportunities.

2. See McGovern 2009 for a treatment of the SSCM knowledge framework

3. Europeam Foundation for Quality Management

Ryfylke: North Sea cost of Ryfylke, Norway

Supply chain mobilization in Fyrbodal (Sweden)

Sweden is the leading country worldwide in using bioenergy. A long forestry tradition and the use of wood and woodchips for district heating is the backbone of this strategy and Sweden is famous for its biogas-for-fuel concept, based mainly on sewage sludge and household wastes. However, new options and approaches are emerging.
The Enercoast regional approach has a focus on two supply chains reflecting this:

- Biogas Brålanda: Upgraded biogas fuel grid – Biogas from manure to vehicles.
- Large scale biomass from forest utilisation

Map of Fyrboldal Region

BACKGROUND FOR THE CONCEPT OF BIOGAS BRÅLANDA

To replace fossil fuels with renewable sources is a major challenge for the society. However, there is also an opportunity for business development in meeting this challenge. Companies, municipalities and organizations within the Fyrbodal region[4] are committed to developing this opportunity.

Biogas production from agricultural crops and manure represents to date a largely unexplored potential in Sweden. In the Fyrbodal region a concept has been developed – Biogas Brålanda – that exploits the potential of biogas production from mainly manure, thereby creating both a positive environmental impact and business development in a rural area.

4. The Fyrbodal region is a sub region of Västra Götaland (West Sweden). The region consists of 14 municipalities and has 258 000 inhabitants. The region has different landscape areas - coastal, agricultural and forest areas.

The Dalbo plain with Brålanda as the center has a potential to develop an industry around biogas for vehicle fuel. Brålanda, situated between Vänersborg and Mellerud, is a community of about 1500 inhabitants. Brålanda is also an important hub on the Dalbo plain, one of Sweden's more coherent agricultural areas. Within the community and its immediate surroundings there are a number of industries and service companies related to agriculture and also an agricultural school, Nuntorp. Geographically, the Dalbo plain is shared between the Vänersborg and Mellerud municipalities.

So far, studies and discussions in both the Västra Götaland region and in Sweden as a whole on biogas production from agricultural manure have concluded that larger biogas plants should be established. However, this requires transporting of the substrate to the plant (digester) and the residue back to the farms. Handling the substrate and the residues from the digestion process becomes a logistical problem and this factor has proven to restrict profitability.

In order to optimize the use of the digestate from the biogas plant as a plant nutrient resource, proximity to arable land is beneficial. The Biogas Brålanda concept connects small farm based biogas plants into a gas grid system, so that larger amounts of energy can be produced. Smaller farm holdings tied together by an infrastructure system is an innovation in biogas production, and it creates a new context for the production of biogas from agriculture. Substrate options for anaerobic digestion is cattle-, pig- and chicken manure and energy crops (grass etc.) at the farm level, as well as slaughterhouse and food industry wastes.

The concept and the 'hallmark' Biogas Brålanda was born through earlier projects and a farmer based company to produce bioenergy had been formed. In addition, the technical and economic opportunities were analysed in respect of locally based small-scale production of biogas and ethanol. The analysis revealed that it would be possible to establish one or more biogas plants on the Dalbo plain and interested farmers grouped together to study biogas production.

Manure is a valuable resource for biogas

SUSTAINABLE SUPPLY CHAIN ANALYSIS OF BIOGAS BRÅLANDA

A detailed supply chain analysis can be found in Lindberg et al (2010). The supply chain featured in this concept consists of the following stages:

Feedstock supply

The total, theoretical and actual biogas potentials of anaerobic digestion have been estimated for the Fyrbodal Region. The study has shown that Fyrbodal has good availability of the substrate needed for producing biogas. Calculations have been made on the basis of the available statistics for organic residual products from the agricultural sector, private households, restaurants, industrial plants and sewage treatment plants. The results show that there is a theoretical potential for producing biogas to the equivalent of 591 461 MWh per year and that there is an actual potential to the equivalent of 243 685 MWh per year, which corresponds to approximately the energy need of 20 300 passenger cars.

Municipalities with a great deal of agricultural land clearly have particularly significant availability of biogas substrate. It is also shown that energy crops on fallow land and straw could make substantial contributions as biogas substrate. However, the anaerobic digestion technology for producing biogas from straw still requires development.

Upgrading biogas facility at biogas plant

Laying down biogas pipeline in Fyrbodal

Biogas plants

The technical approach being considered in the Biogas Brålanda concept is to use manure in a digester with a yearly capacity of 8-30,000 tonnes of manure. This means that both biogas plants on individual farms, and common biogas plants with cattle and pig manure from several farms will be established. The substrate is pumped from the stables to a digestion chamber, a distance of 0.5 - 3.0 km. Pumping is of great advantage as the cost is calculated at 5 -15 SEK/m3 compared to vehicle transport with costs of 15 -20 SEK/m3.

The reason for considering the digestion of manure from several farms together is the challenge in transporting the crude gas. When leaving the digester, the crude gas is saturated with water vapour and when the gas is cooled, the water condenses. This condensed water has to be removed; otherwise the water will block the gas in the pipes. The water is removed by drying or compression and cooling. This handling imposes great expenses by techniques known today.

Pumping manure from farms into a common digester is thus a solution to handling manure, and other substrates, with technology known today.

The challenge has been to work with manufacturers and with research expertise to find an optimum pumping and homogenisation system for the substrate and appropriate technologies for small-scale gas production units as well as the optimization of the digester process for optimal biogas production.

Faced with the design of joint biogas plants risks of infection have been examined. A research study has been conducted on sanitation technologies. Contacts have been established with officers of the Board of Agriculture to investigate changes in the regulation of the handling of organic wastes. A dialogue will develop with the relevant authorities responsible for regulation of the biogas production in order to adapt the regulation to biogas plants on farms.

Local distribution of crude biogas

Transport of dry gas presents a risk of condensation with the pipes having to be equipped with a drainage system. A cheap simple alternative to dry gas would create significant benefits for the local gas network. Several companies and technology developers have been contacted to find simple solutions. These have been identified and valued.

Use of gas

Production of electricity / heat or heat alone for local markets

The conditions for the production of biogas from farms for heat or electricity and heat with a view to replacing oil used by local industries in Brålanda.

Upgrading to vehicle fuel

An upgrade of the gas to vehicle fuel is planned centrally at a plant in Brålanda. The concept has explored the technical and financial capacity of a pilot plant of this kind.

Farm vehicle fuel

Methane gas may well be used for tractors, harvesters and other farm vehicles. One step in this development is the use of dual-fuel technology, in which methane gas is released into the throttle through the inlet air to the engine, and about 10% diesel and other synthetic replacement is deployed as lighter fluid. A simple technique needs to be developed so that methane can be stored in tanks on the vehicle, either compressed at a high pressure of about 600 bar or in a liquid form. The project has explored what is available on the market and promoted technology development.

Biogas Brålanda supply chain gaps

The SSCM analysis of the Biogas Brålanda concept is published in Lindberg et al 2010 and reveals a dynamic and complicated situation. In the following we will discuss the relevant gaps and opportunities in relation to supply chain mobilization.

Status before Enercoast

- Raw material (manure): Existing but not utilized for biogas production
- Logistics systems: Non-existing
- Units for production of biogas from manure: Non-existing
- Distribution systems: Non-existing
- Market (gas for vehicles): Existing and growing

Identified gaps in the Supply Chain

Gap 1: Lack of integrated business models throughout the value chain.

The process of analyzing the value chain, of finding forms of cooperation between the actors in the business chain, of finding technical solutions for the further development, as well as conditions for the outlet of gas, in particular to the public transport sector, has been ongoing.

The greatest challenge identified is to get all the jigsaw pieces to fall into place at the same time; i.e. to synchronize biogas production for vehicle fuel with the build-up of a market ready to accept it. In addition, the risk factor with a relatively new value chain is obvious. This means a new service developed by the agricultural sector and developing completely new forms of cooperation between operators who have not previously cooperated, for example energy companies and individual farmers.

To establish trusting relationships between the different operators of the value chain is crucial for success. In addition, vehicle fuel customers need to feel confidence in order to invest in a new product for managing their cars and buses. In another Innovatum project work has been done on the development of a biogas Saab, which is expected to assume great importance for the bio-enterprise development of the Fyrbodal region.

Process stage options to be pursued:

- Develop business plans for stakeholders
- Establish working groups for each step in the value chain
- Creation of business organizations/platforms

Gap 2: Production costs too high

WP 1 of Enercoast showed a need for the operators to have a more overall picture and knowledge compilation of the potential for biogas in the Fyrbodal Region to make it possible to analyze the gaps of the supply chain (WP 2 and 3). Together with the Fyrbodal municipal association and the Swedish Rural Economy and Agricultural Society, an inquiry into the biogas potential of the digestion of residues from agriculture, industries and sewage sludge for the entire Fyrbodal region, has been conducted and presented in the form of a report with maps for each municipality (WP 2).

This base provides good reference data for decision-making in respect of further activities to promote supply chain development in the Fyrbodal region.

Process stage options to be pursued:

- Survey on biogas raw material in Fyrbodal
- Pilot project manure distribution system
- Marketing and promotion towards main end consumers

Gap 3: Lack of infrastructure

As a result of the data acquired through the potential study (see gap 2 above) undertaken in the framework of this concept, stakeholders have identified a gap in the supply chain and therefore called for a better basis for the planning of the physical infrastructure for biogas distribution in the Fyrbodal and Skaraborg regions. This planning has been completed via a partnership with Fyrbodal and Skaraborg municipal associations, energy companies, the Swedish Farmer's Association (LRF), the Swedish mapping, cadastral and land registration authority. Focus has been on how the process of developing the base (WP1, WP2 and WP3) as well as defining its scope (WP2). The aim is that the process of producing the base will become a part of the mobilisation of parts of the supply chain (WP3) which then can carry out investments in infrastructure works. The work will be carried out in collaboration with the neighbouring region Skaraborg.

In a co-operation with participants from public and private sectors a strategy for The Region of Lake Vänern has been developed (WP1 and 2). Innovatum has had the responsibility of developing parts of the strategy, namely "Lake Vänern and energy utilization" which has resulted, inter alia, in proposals for an infrastructure for biogas for vehicles for the entire region of Lake Vänern. The plan is at present being evaluated politically. In a dedicated workshop the Board of the Fyrbodal Municipal Association has analyzed the gaps related to the biogas supply chain in Fyrbodal.

At Chalmers University of Technology, Gothenburg, a study has been carried out regarding biogas to vehicle fuel in the form of liquid methane. The study proposes appropriate upgrading technology for the Biogas Brålanda concept.

Process stage options to be pursued:

- Infrastructure planning for the whole region of Fyrbodal
- Evaluation of the infrastructure of Biogas Brålanda
- Evaluation of upgrading for liquefied methane
- Evaluation of small-scaled upgrading plant

Gap 4: Lack of knowledge transferring about biogas production on a farm level for upgrading

Process stage options to be pursued:

- Seminars/work-shops

Gap 5: Lack of long-termed business agreement

Process stage options to be pursued:

- Political agreement on buses in public transportation

Gap 6: Still few cars in public sector are driven on biogas

According to a study regarding investigation of the market for biogas for vehicle fuel from Biogas Brålanda, the potential for vehicle fuel from biogas far exceeds the potential of manure-based biogas production in the area. Cars and buses form a significant proportion of the potential, but heavy traffic shows the greatest potential. This will, however, require the development of new engines that meet industry requirements for strength and scope. Duel-Fuel technology for biogas in diesel engines is an absolute must for truck companies.

The market potential should therefore not present any restriction on the Biogas Brålanda concept.
To get started development requires rapid and clear decisions from the politicians, where priority is given to biogas deployment in vehicles and transportation. This should prove politically acceptable, because the biogas is today's most environmentally friendly fuel and cost-neutral for the end consumer, at least for cars.

Biogas creates jobs at home while other bioenergy products, such as ethanol and biodiesel, are traded on world markets. This requires an effective information campaign to politicians and senior officials in the public sector.

Process stage options to be pursued:

- Knowledge about public procurement
- Information/communication politicians

Biogas Brålanda supply chain mobilisation and business optimization

The following actions and measures have been initiated to support the supply chain mobilisation and the involvement of key stakeholders throughout the supply chain.

Business organization

Within the Biogas Brålanda concept the development of the organizational structures is currently underway. The concept proposes that a number of small bio-gas producers, with about five members each, are formed around an anaerobic digestion plant or another component of the biogas supply chain. These smaller associations are party to a more comprehensive economic association, Dalslands Bioenergy, a cooperative for joint ventures such as connecting major pipelines. This larger economic cooperative in turn is a member of the newly formed corporation Dalslands Bioenergy AB, whose main task is to buy, sell and process gas and settle the appropriate contracts. This organization ensures that local entrepreneurs can be involved as owners in the entire chain from producer to consumer as well as in the technology development work.

The concept will be implemented as a guide to structuring the organisational formalities such as financing (shares, stocks, etc.), agreements between different parties and the responsibility for the infrastructure. Many of the issues require specialized fields of judicial expertise. The goal is an organizational structure allowing local producers to become partners in the whole chain up to the market, but also enabling other parties beyond the producers to participate as funders of the various components of the supply chain.

A calculation tool has been developed for cost-benefit calculations for biogas applications. The main requirement was that the tool could calculate the return on projects on the basis of an internal rate of return on investment over a 20-year term. The calculator tool can also generate profit and loss statement and relate cash flow analyses to given boundary conditions. In addition, simulations and hence the visualisation of the framework context an easily be presented in graphical form. The calculator tool has proved very useful in highlighting the economic framework of the venture.

Within the Biogas Brålanda concept the technical, economic and institutional conditions needed to initiate the start of the construction of production facilities have been specified. The work was carried in close collaboration with the farmers involved.

Infrastructure

An infrastructure for bio-gas pipelines can be divided into different types depending on stakeholder location and how many stakeholders are involved.

- The least complex form is the connection between an individual farm and a digestion plant.
- A second form is a pipeline between a farm and digestion plants where several producers are connected.
- A third form is the pipeline from the digestion plant to the main pipeline.
- Finally, the fourth type is the main pipeline leading from Mellerud to Vänersborg (around 50 km) and possibly on to the neighbouring towns of Trollhättan and Uddevalla.

All types of pipelines demand different formal measures such as permit decisions, agreements between users, building permits, environmental permits and easements. The concept has identified economic, legal and geographic requirements and has been instrumental in overcoming formal barriers to initiating the construction of the main pipeline and connecting pipelines.

Market

The concept will identify and clarify the market for the produced gas. Prospective consumers have been outlined and the whole cost from producer to the paying consumer has been outlined.

Rules and legislation

A compilation of all rules and legislation covering the supply chain of biogas production has been made.

Current status

In November 2009 the construction of the first biogas plant started and it will be completed in September 2010. At the same time the construction of the main pipeline started. The digestion plant will be connected to the main pipeline and initially deliver gas for heating a slaughterhouse and the farm-owned heating plant in Brålanda. The first biogas plant will have a capacity to digest 10,000 ton pig manure per year as a first step. It will produce an energy equivalent to 1500 GWh per year. The total investment in the plant is 5 mio SEK which includes a grant from the Swedish Rural Development Programme of 1,5 mio SEK.

The main pipeline has two gas pipes, one with a diameter of 160 mm for the crude gas and one of 90 mm for the cleaned gas. The first part is 4,6 km long. From the digestion plant one manure/digestate pipe will deliver the waste to a neighbouring farmer who will store it and use it as fertilizer.

The Biogas Brålanda concept was one of the award winning projects at the Swedish Rural Gala in September 2009. The project won the prize for the best environmental project.

LARGE SCALE BIOMASS FROM FOREST UTILISTAION

The decision-makers group "Lake Vänern and energy utilisation" has conducted studies on thefuel refinery and logistic centre at Vargön Industrial site (incl. harbour). This approach involves large companies (Göteborg Energi, Vattenfall, Trollhättan Energi AB) and the pulp & paper industry Holmen Paper AB and the Trollhättan and Vänersborgs municipalites.

The idea is to bring in low-value biomass materials and transform into better and more valuable biomass fuels. The challenge is to get as high an energy exchange as possible and to switch between various high-quality products to maximize the income.

Woody biomass from Swedish forests

Sustainable supply chain analysis of forest biomass

The barriers that exist in general for the establishment of a bioenergy combination in addition to the viability of technical solutions and the location include:

- **Funding and profitability:** The establishment of a bioenergy combination requires large investments and the repayment/remission on the long term. In other words, stakeholders who can deal with large balance sheets are required.
- **Technology development and selection:** Several elements of the technology that can be used in a bioenergy combination today are not technically fully developed and/or require certain specific conditions to operate.
- **Raw material supply and logistics:** A bioenergy combination requires large amounts of input in the form of various types of biomass and a specified output. Price and availability of raw materials can vary greatly and it is difficult to get stake holders to sign long-term contracts. There is also some uncertainty in the market with regard to prices and availability of various forest fuels.
- **Organization:** The organization and control of a bioenergy combination reflects broadly its operational demands. When a bioenergy combination is to accommodate several actors needed for steam, electricity, pellets, biofuels, hot water etc., it also de mands an organization involving many different stakeholders. This, together with the roles of several owners and financiers, creates some obstacles (but also opportuni ties).

From a general perspective the opportunities presented by a combined bioenergy plant include:

- **Resource Optimization:** The co-location of several types of activities gives the oppor tunity to optimize investment in plant and obtain higher yields. Investment in opera tions such as steam, electricity and hot water production can be shared in a cogenera tion unit. The availability of cheap and good raw material in the area creates the conditions for profitable production of pellets.
- **Energy efficiency:** By clever design of a bioenergy combination it is possible to ob tain maximum energy from primary fuels and also to select the energy carrier which has a maximum market value.
- **Administration and organization:** By "sharing" a large site it is possible to get econo mies of scale in terms of operation, maintenance and administration costs.

Status before Enercoast project

- Raw material: Large amounts of biomass are utilised. However, still large amounts are not exploited due to several reasons.
- Logistics systems: Well developed for wood chips to nearby DH/CHP plants. Logistic systems for transport by boat in Lake Vänern and Göta Älv are not very developed. Improvements and legislative measures etc. are under evaluation
- Production: Almost all towns and cities have DH/CHP plants fuelled with wood chips. However large scale CHP and biofuel production plants are planned or are currently under investigation.
- Distribution systems:
  - Electricity grid: Well developed, no problems with connections or alike
  - DH grid: Existing and continuously extended to new areas or becoming more dense
  - Biofuels: More and more filling stations and vehicles on the market

- Use: District heating is a well known and favourable solution, even for industries
  - Increasing use of electricity
  - New and rapidly increasing markets for biofuels (biomethane, synthetic gas etc)

Identified gaps

The market need for forest based biomass is increasing due to increased use in DH/CHP and pellet production. This has lead to increased prices and thus incentives for forest owners and contractors to take out biomass when thinning and harvesting. New, large scale, polygeneration and biofuel production plants will enhance this development.

Thus the gaps within the supply chain are:
Gap 1: Energy- and cost efficient logistics for large scale outtake and users
Gap 2: Better/more homogenous quality on wood chips or other biomass fuels

The stakeholders are now proceeding with the identified possibilities to establish the option of refinery of low value biomass (drying of biomass, chipping/mixture/compression, storage and logistics, terminal operations).

Forest Biomass supply chain mobilisation

The following actions and measures have been initiated to support the supply chain mobilisation and the involvement of key stakeholders throughout the supply chain.

An investigation on large scale handling, logistics and supply of wood chips on the industrial site of a former paper mill called Vargön has been carried out. The investigation was a result of the outcomes and suggestions from discussions between a dedicated group of people set up by Innovatum. The group consists of both public and private stakeholders. The investigation analyzed the possibilities to use the industrial site as refinery, storage and logistic centre for large scale handling of wood fuels. This is based on the site's favourable conditions in terms of facilities (buildings, storage plot and boiler) and location (roads, train and harbour).

The results of the investigation showed both interesting results in terms of economics of new wood energy operation on site as well as potential stakeholders and investors (utilities, municipalities etc.). The main options presented are:

- Processing of biomass for electricity, heat, power production
- Pellet production
- Refinery of low value biomass (drying of biomass, chipping/mixture/compression, storage and logistics, terminal)

Based on information obtained in the investigation the first two possibilities have been favoured.

Processing of biomass fuels for electricity / heat / power production

This location is interesting from the perspective that large parts of the facilities in Vargön could be used. The volume to be handled on site should be optimized in terms of the waste heat and excess capacity throughout the year. It is difficult to develop a convincing business plan without a plant without getting paid more for the dry fuel in relation to the energy content of a wetter fuel. Further discussions with stakeholders are needed to establish cooperation/co-ownership of the facility and logistics optimization and also for optimization of the use of the produced heat.

Pellet production

A pellet production line where the existing boiler and the waste heat from a nearby factory could be used should be able to provide a good return on capital. Ongoing development in this area is needed. This should be done in coordination with the stakeholders once both options can be quite easily integrated with each other for cost-effective use of drying equipment and waste heat.

The following questions and actions should be investigated further:

- Identify resources and markets. A deeper investigation of biomass flows and poten tial should be conducted to identify the volumes, prices, key stakeholders and poten tial obstacles and opportunities. The investigation should focus on the geographic area around Vargön, but even include volumes that could be transported over the lake Vänern or from major customers within a larger radius accessible by road or rail transport.
- System design/optimization based on demand, resources and economy. Technical ex pertise is required to produce a more detailed basis for analyzing the technological and economical feasibility of a biomass fuel business.
- Which stakeholders are important to interact with and what are their incentives to contribute to an increased use and processing of biomass in the area?
- How can other industrial stakeholders be involved in the development work?
    - How can cooperation on raw material logistics be built up in discussions with energy and forest industries.
    - Which stakeholders could/should be the owner of the facility?
    - Should the plant be a separate company that sells/buys to other businesses or should the different elements be vested in various companies?

The stakeholders are now proceeding to explore the identified possibilities of establishing a refinery of low value biomass (drying of biomass, chipping/mixture/compression, storage and logistics, terminal).

Supply chain mobilization in Central Denmark Region

BACKGROUND

In Denmark, renewable energy and bioenergy has been on the agenda for several decades. In 2007, Denmark gained 17% its of gross energy consumption from renewables, 3% from wind turbines, 3% from organic (municipal) waste and 10% from biomass.

The official goal is to reach 30% renewables by 2020, where wind turbines and especially biomasses are expected to replace a large proportion of coal and natural gas fired CHP plants for district heating. This should come from forests (nationally and imported) and from energy crop cultivation, which so far has been very scarce. In addition, energy utilization of manure (mainly biogas) is expected to increase tenfold compared to present situation by 2020. The national initiative Green Growth launched in 2009 has a strong focus on biogas and energy crop cultivation in order to meet both the EU and national bioenergy targets and environmental goals of the Water Framework Directive.

The Central Denmark Region[5] is specialised within the energy and environmental sector and has an absolute position of strength within the wind and biomass areas. The ambition is to reach 50% renewables in energy consumption by 2025, and much focus is on bioenergy in the region. Randers, Norddjurs and Syddjurs municipalities are also ambitious on the bioenergy issue as well and have recently adopted strategic plans for energy and heating. The major 'black box' in these plans to reduce Green House Gas emissions is the consumption of transport fuel, where the fossil fuels cannot easily be replaced at present.

A few relevant characteristics could be mentioned about the Danish Energy system:

- District Heating (mostly Combined Heat and Power production) is found in every town and 62% of all Danish houses are connected to the system.
    - Most of this energy is still coal or natural gas fired, but changes are coming (two plants partly using coal and several gas fired DH in the three Enercoast municipalities)
    - Wood chips, wood pellets and straw are commonly used
    - Household Wastes are generally incinerated in Denmark for DH
    - District heating is generally a non-profit activity by law to protect the end user from abrupt changes
- 27% of straw is used for energy production in the Central Denmark region
- A total of approx. 150 biogas plants in Denmark,
    - half of these are public and based on sewage sludge
    - 60 farm scale plants based on manure and industrial wastes
    - 22 large cooperative plants based on manure and industrial wastes
        - The gas is used for CHP and district heating

More details can be found in the Sustainable Supply Chain Analysis report (EA 2010a) and the Local and regional market for Bioenergy report (EA 2010b).

5. Central Denmark Region has 1,2 mio. inhabitants in 19 municipalities. The region is characterized as mainly agricultural land with the best soils in the eastern parts, except for Djursland. Randers Municipality has 95.000, Syddjurs Municipality has 41.000 and Norddjurs Municipality has 38.000 inhabitants

In Denmark, the Enercoast sub-project has decided to focus on the improvement of two already existing supply chains quite characteristic of the country, the Central Denmark Region and the three involved Municipalities. This selection has been made both for 'internal' improvement of these two supply chains and for the inspiration of the other North Sea Regions. We have chosen to focus on two major supply chains, both with several 'sub-supply chains', or alternative pathways i.e. several different options for new and alternative biomass supply that exist or are under development.

The influence of Enercoast activities on the two selected supply chains will be quite indirect and less tangible compared to some of the supply chains in other regions in Enercoast. A mixture of environmental research, methodology development and supply chain analysis and market reports are the major outcomes.

This in turn should catalyze the installment of more bioenergy plants and improved supply chains – and thereby more hectare of land for energy cultivation etc. But these latter outcomes are not directly influenced by Enercoast activities, and therefore we cannot claim them to be results of Enercoast interference.

However, a major influence can be generated through the development of the biomass inventory tool needed for the municipalities to actually give a status of use and potential use of biomass for energy.In addition, concepts for Business plans (e.g. for biogas plants, for farmers producing energy crops or foresters changing production towards energy crops) can be rather direct outcomes of the project.

SLURRY BASED COOPERATIVE BIOGAS FOR DISTRICT HEATING

Denmark has a strong tradition among famers of organizing cooperative solutions to common problems. Such an example is cooperative biogas plants, typically owned and run in a separate company by a group of farmers, sometimes jointly with the district heating company or other stakeholders. The idea behind this construction is to process farm manure by anaerobic digestion giving rise to effective re-distribution of nutrients to plant production. When manure from dairy farms and pig farms are mixed, a better balance of e.g. phosphor is achieved in the digestate. The digestate is easier to use and readily taken up by plants reducing runoff and leaching of nutrients. One major target for cooperative biogas production is the production and redistribution of suitable fertilizers.

The organisational structure, which is characterized by relatively large plants, is suited to providing a stable economic basis with professional management, although the conditions for the sale of the resulting power are much less attractive compared to other countries. Therefore, biogas production in co-operative plants is linked up to district heating, so that the CHP gives efficient use of the energy potential. Hitherto slurry and industrial waste has been treated, but increasingly separated slurry fibers and energy crops will be input into biogas plants, opening up new market opportunities for farmers. Based on liquid manure and additional high energy biomasses the production of gas for CHP has many business opportunities, but also some constraints.

The supply chain is common in Denmark, but rarely found in other North Sea Regions. However, only two small farm scale biogas plants exist by now in the three municipalities, but 2-3 larger cooperative biogas plants are under planning (one in each municipality). The supply chain is generally well known and well established, but the business has hardly

Large Danish Biogas plant (photo Biogassekretariatet)

developed during the last decade in DK, where only two new cooperative large biogas plants have been built in the country. The stakeholders find the frame conditions (feeding tariff of 0.1 €/kWhel) simply too low and the environmental approval is too complicated and slow.

Now the national focus is very much on this supply chain due to the Green Growth Plan with investment support (20% of investment), public guaranteed credits and new initiatives to open the market for biogas (feeding into the Natural Gas Grid). Still, however, the official goal is to replace fossil fuels in district heating with biogas, which has led to a discussion of whether to localize the large agro-industrial plants near the biomass source (open agricultural land) or near the energy consumption (larger towns). This specific focus of the establishment of new biogas plants is being addressed in a new manual for establishment of biogas plants in Denmark (Tybirk et al 2010)

The time is right to focus on this particular supply chain as it needs to be developed further in many aspects. One aspect is to find the best alternative high energy biomasses to add on to the slurry – as slurry will continue to be the main basic biomass source for biogas in Denmark.

Key stakeholders

The key stakeholders in the biogas business are numerous.

- Famers and their associations (including the Biogas Association) play a major role
    - typically as plant owners (share holders)
    - producers of slurry and energy crops
    - typically also as users of the degasified slurry for crop production
- The daily manager of the biogas plant play an important role
    - in buying and mixing the right biomasses to get the optimal gas production
    - in finding the cheapest biomass
    - optimal redistributions of the slurry for crops
- The CHP plants and the energy consumers play a key role in having a non-profit monopolies' status for the purchase of the gas
    - The biogas company has few (if any) alternative pathways for marketing of the gas
- The municipalities and the newly established ministerial Biogas Secretariat has a key role
    - In finding suitable locations
    - In ensuring smooth environmental approval
- Advisory services and companies play a key role in advising farmers and preparing investment
- Neighbours, NGO's, and the energy consumers are important stakeholders and play a key role in finding locations for new plants.

Normally, the initiative for a cooperative biogas plant comes from a group of farmers. They have a strong particular motivation in having their slurry treated and may – due to interpretations of fertilizer rules in Denmark - achieve a net benefit in their own nutrient accounting by using degasified slurry. The biogas plant enables in fact the farmers to increase their animal production and fertilize more (which are highly motivating factors) resulting in either higher profit from plant production – and/or a risk of leaching more nitrogen to the aquatic environment.

Experimental plots of perennial bioenergy crops

Key Indicators

The Supply Chain Analysis (EA 2010) has revealed that the key indicators for this supply chain are:

- Frame conditions (economic indicator)
    - Investment support (20%),
    - Subsidy of 0,1 €/kWhel.;
    - non-profit principle of district heating
- Supply of good quality biomass at reasonable price (economic and environmental indicator)
- Recycling of nutrients (economic and environmental indicator)
- Green House Gas balance (environmental indicator)
- Smell and local transportation (social indicator)
    - Localisation (social, environmental indicator)
- Regular gas production from biogas throughout the year , but very irregular (seasonal) district heating demands (economic indicator)

Gaps and options

The identified major gaps and options for improvement of the supply chain are:

Gaps	Options
Manure based biogas needs additional biomass	Energy crops and nature conservation bio-masses
Unexploited potential of alternative biomass resources	Research and inventory tool needed
Present frame conditions	Increased and graduated subsidies
No credits available due to financial crisis	Municipality guaranteed loan
Alternative market for gas	Upgrading for gas grid, replacement of fossil gas
	Upgrading for transport fuel
Social acceptance of biogas (NIMBYs[6])	Open participatory planning process
Guaranteed sale/ price of energy	Long term contracts
Lack of planning process knowledge among stakeholders	Process planning manual under develop-ment

Targets

The explicit goal of the municipalities is the establishment of one larger cooperative biogas plant in both Norddjurs and Syddjurs Municipalities.
Randers Municipality will build a biogas plan with focus on the use of local biomass resources to replace fossil gas.

Enercoast intervention

The realisation of these targets is not solely dependent on Enercoast, but the project can catalyse the process towards more biogas by improving the knowledge on biomass resources, improving the communication among stakeholders and bringing in planning process knowledge. The project intervention will focus on developing the tool for biomass inventory, scenarios for changed crop production (including new biomasses for biogas) and on calculating the resulting environmental effects/ benefits.

6. NIMBY: Not In My Back Yard

Willow (Salix) shoots for woodchips

In addition, Enercoast pilot studies could focus on

- testing silage production and logistics relating to the planned 10 m river and lake buffer zones
- developing realistic business plans for new biogas plants
- adapting the German Multicriteria Decisions Support Analysis tool for Danish biogas planning.

Business optimization strategies

Numerous factors play a role in making an optimum business plan, e.g. for the planned new biogas plans in the three municipalities. The business plan for the planned biogas plant at Andi was the basis for the decision in 2009, and for the application for environmental approval. Contracts for building the plant are expected to be signed during 2010.

The planned biogas plant near Grenaa is still lacking the key purchaser of the energy. Many options are at stake, as a new Bioethanol plant at Grenaa Harbour is being planned. This will require a lot of energy that could come from biogas.

The specific business plans are out of the scope of Enercoast as the private company Djurs Bio-energy is doing the planning, but Enercoast is – through the municipalities and Agro Busines Park - involved in dialogue with the company.

SOLID BIOMASSES FOR DISTRICT HEATING

Straw for district heating, woodchips and pellets for CHP have potential business opportunities for more producers to the local/regional market. In addition to this, but not treated as a supply chain in Enercoast, there is a strong tradition of individual domestic heating based on firewood or wood pellets, and numerous farms are powered by their own straw.

The supply chain of solid biomasses for DH is relatively common in Denmark and in the involved Randers, Norddjurs and Syddjurs municipalities. 16 biomass fired plants are in operation at present in these municipalities. We have many specific experiences with straw, municipal waste, woodchips and wood pellets that could be useful in other NSR countries. The different input biomasses have different characteristics, but quite a few things in common, and therefore they are described as a common supply chain.

For the time being, this supply chain is developing as several coal and natural gas fired plants are expected to switch to biomass fuels during the coming years. Verdo in Randers has almost completely switched to different biomass fuels (from local producers, but also from Baltic States and the UK) and Grenå Varmeværk is looking for alternatives to coal.

A detailed Supply Chain Analysis can be found in EA (2010a).

Key stakeholders

The key stakeholders in the solid biomass business are numerous and are analysed in depth in EA (2010a).

Key stakeholders identified are

- Farmers producing straw and potential energy crops, such as Miscanthus (elephant grass) and Salix (willow) chips

- Foresters producing wood chips.
    - The amount of woodchip produced depends on marked prices of round wood versus chips
- Pellet producers (from national and international sources)
- Waste companies dealing in household and industrial waste
- The CHP or heat plants
    - Private or municipal
- The District Heating Association
- Energy consumers (end users demanding cheap heat),
- Municipalities through energy planning and/or co-ownership of the DH plants
- Biomass traders (Three major in the region: Verdo, Danish Land Development Service – Hedeselskabet, Danish Forestry Extension - Skovdyrkerforeningerne).

Key Indicators

The Supply Chain Analysis has revealed that the key indicators of this supply chain are

- The supply and price of biomass locally and/or internationally, (economic indicator)
    - New subsidies for willow plantations from 2010 (3200 dkk/ha)
    - Amounts produced/sold depends on price
    - Quality differs
- Stable and rational local production (economic indicator)
    - To secure deliveries
    - Long term contracts
    - Secure local jobs
- Logistics (economic and environmental indicator)
    - bulk shiploads from the Baltic states versus local road transport
    - storage (energy density, kWh/t)
- Potential corrosive effect of straw (economic and environmental indicator)
- Recycling of nutrients and hazardous substances (economic and environmental indicator)
    - phosphor ash
    - heavy metal ash
- Internal competition between straw, willow and wood chips (economic indicator)
    - Flexible boilers
    - New market developments

Social aspects do not play any major role in this supply chain as it is well accepted and generally unproblematic.

Gaps and options

The identified major gaps and options for improvement of the supply chain are

Gaps	Options
Consequences of increased production of solid dry energy crops for landscape and environment (water plans and GHG emission balances)	to document/model these facts
Price for producers and users are challenged by new competitors (bioethanol from straw, bulk carriers of woodchips etc)	1) to improve productivity of e.g. willow, straw and local woodchips.
	2) prices are expected to increase over time as the resources are becoming scarce
Straw is a subsidized biomass only for heating	competitive advantages
The potential – but yet unexploited - supply of willow chips and gardening waste for CHP	research and inventory tool needed
Willow production and handling for dry wood-chip production is yet unexploited	logistic optimization

Targets

A major goal for the involved municipalities is to decrease the CO2 emission, but already now 55-85% of the district heating is based on biomasses in the three municipalities. In Syddjurs municipality 85% of the district heating consumption is covered by biomass, but the municipality has a relatively high percentage of individual heating, often based on oil or electricity. However, bioenergy production should not be seen as limited by consumption within municipality borders as increased future biomass production can probably be sold at nearby markets, e.g. the city of Aarhus.

Enercoast intervention will focus on developing the tool for biomass inventory, scenarios for changed crop production (biomasses for biogas) and the resulting environmental effects/ benefits. The catalyst function of the project should not be neclected. Bringing together the Stakeholoders may lead to new business contracts ads has been the case with Verdo in Randers establishing new contacts with forest managers locally.

In addition Enercoast pilot study themes could be

- The use of reed in fjords for bioenergy purposes
- Evaluation of bioenergy production as an alternative to wheatproduction in vulnerable areas
- to test of willow shoot logistics for dry chipping
- to make business plans for parts of the supply chain (e.g. Biomass producers).
- to establish a demonstration plan of Miscanthus for district heating

Business optimization strategies for selected Supply chains

Alternative biomasses, such as Miscanthus, could open up new business opportunities. Willow shoot logistics also need improving to obtain better quality chips.

Supply chain mobilization in Lower Saxony (Germany)

Maize for biogas is controversial in Lower Saxony

BACKGROUND

Germany is known internationally as the leading country in biogas production. In 2007 Germany accounted for almost 50% of EU 27 electricity production based on biogas – and this development continues, due to favourable incentives. Almost 5000 plants are in operation , and a few of these inject the gas into the grid.

The biogas produced is mostly based on slurry and maize and this has converted many agricultural areas in Germany from mainly dairy producing to energy producing. This has given rise to quite some debate on agricultural production in some areas, the "food versus fuel" debate.

Farming in Lower Saxony[7] has also experienced big changes over the years. The average size of a farm has grown from about 16 hectares of farmed land in 1971 to more than 50 hectares in 2007. Technological advances have led to huge increases in productivity in the stables and on the field. Even though agriculture in Lower Saxony is still characterised by family farms, modern farm managers see themselves increasingly as businessmen, who understand are as familiar with least as much about marketing and business administration as with production techniques.

Biogas is booming in Lower Saxony. About 600 plants have been established, most of them based on maize. However, alternative biomasses for biogas are currently being sought as the production of maize is confronted with its limits. In the regional part of the Enercoast project, the Chamber of Agriculture in Lower Saxony has chosen two sustainable supply chains that will be investigated and a proposal for optimisation will be worked out. In addition to this, University of Oldenburg had proposed to work on a supply chain for coastal algae for biomass.

7. Lower Saxony is second in area and fourth in population among the sixteen states of Germany. And it located in the north western part of Germany

Fibres of digestate used for animal bedding after drying

MAIZE TO BIOGAS

This sustainable supply chain represents the established and well working supply chain for biogas production. The main input energy crop for biogas is typically maize. In order to reach the EU targets on renewable energies it is - in the opinion of many experts - necessary to raise the energy production from biomass energy. In some regions the share of maize in the crop rotation has reached a level that it can not be expanded more – due to social factors, among others. So the efficiency of biogas production has to be raised.

In the following, the analysis of the second supply chain for dike biomass can – if successful - be transferred to the maize to biogas supply chain.

DIKE BIOMASS TO BIOGAS

As explained above, the amount of maize is limited. In the pilot region, the Municipality of Dornum in the North-West of Lower Saxony the Chamber of Agriculture together with the LUFA Nord-West laboratories are currently investigating new potential biomasses. This focus is on biomasses which up till now have not been used for biogas, but could become a potential input for both the established and new biogas plants. The materials focussed on are those growing on fallows, road verges, algae and seaweed together with inputs from local farms such as liquid manure and waste. The aim is to find biomass resources which do not compete with the food and fodder production.

Selected indicators

The indicators can be divided into three groups: economic, ecological and social indicators. For each group, one main indicator can be pointed out which is linked to other targets and their criteria or other targets which are constrains of the main target of each group

Economic criteria:

The main economic criteria respond to the EU targets on renewable energies. In order to reach the prescribed share of renewable energies an additional energy yield from biomass is necessary. So the main indicator is **the additional energy yield.**

This additional energy yield should come from yet unutilized potentials, such as the investigated materials. For an economic assessment questions it is important that the supply chain or the specific material is competitive up against the established technology. Hence which is defined by the indicator "costs per production unit" has been selected. The target here is to minimize the operational costs.

Ecological criteria:

The main ecological indicator is **the saving of CO2 equivalents.** This target can be achieved either by an improvement of the biomass technology or by more substitution of fossil fuels by biomass. The aim of the work from the Chamber of Agriculture is to explore biomasses that are not yet being used yet and which do not compete with the food or fodder production, because this would lead to a competition between both uses.

One constraint to the saving of CO2 equivalent is the biodiversity which needs at least to be constant - or better improved.

Social criteria

The most important social indicator is **the positive image for bioenergy.** This can be achieved by the social acceptance of bioenergy.

To achieve this target, bioenergy cannot reduce the food and fodder supply (food vs. fuel discussion), must provide and secure employment and minimize environmental impacts. Also the preservation of biodiversity is an important image factor , so biodiversity can be considered both an ecological and a social indicator.

Status before project

Due to the Erneuerbare Energien Gesetz (EEG) (Renewable Energy Law), that makes bioenergy in Germany an attractive field to work with and invest in, biogas has been a growing industry over the last decade.

The common input is maize. Only few biogas plants use waste from industry (e.g. from slaughterhouses, food production) due to the favourable tariffs for biogas electricity production based on the use of agricultural products such as maize and liquid manure fed to the biogas plants. Some materials which have not been tested for biogas so far (from fallows, road verges, algae and seaweed) might be an alternative to maize.

Key stakeholders

In the work with the project two levels of stakeholders have been identified:

1. Level: Expert group

This group consists of representatives from the pilot region Gemeinde Dornum (mayor and chamberlain), interested farmers who are interested in investing in a biogas plant run on alternative input materials and persons who already have a broad experience in the biogas business.

There are professional exchanges between this group through meetings and field trips/visits.

2. Level: extended stakeholder group

In this group all identified stakeholders are included, such as

- Nature conservation organisation
- Water and dike boards
- Farmers association
- Wadden Sea secretariat
- Municipal business development agencies
- Ministry of environment
- Ministry of agriculture

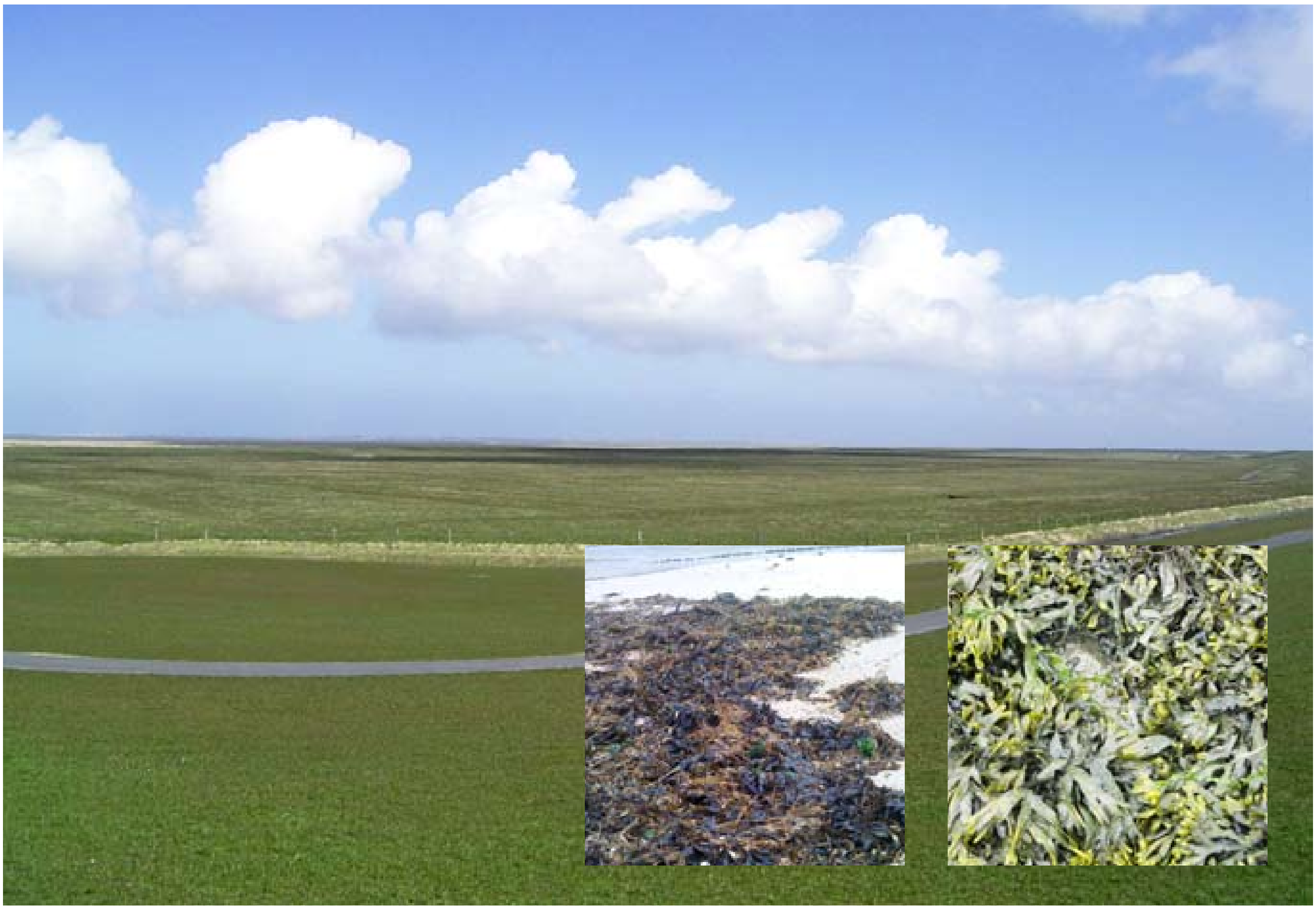
These stakeholder are informed about the progress of the project at least once a year through a stakeholder meeting and they are involved on demand for the project

Identified gaps in regional supply chains

- There is a research gap concerning the cultivation, harvest and storage of fallow and game seed mixtures
- There is a lack of testing of alternative materials in biogas plants
- Information gap on the potential for bioenergy in the region (quantity, quality and availability of materials).

Targets in our supply chain optimisation work

- Boost sustainable bioenergy production
- Establish the full supply chain to generate added value in the region



Coastal Wadden Sea area of Lower Saxony with bioenergy potentials. Algae and beach-cast seaweed wrack is being investigated

- Show up synergistic effects between:
    - nature conservation and agriculture/bioenergy
    - tourism and agriculture/bioenergy
    - water economy and agriculture/bioenergy
    - fishing industry and agriculture/bioenergy

Enercoast intervention - pilot projects planned/started

On the experimental farm "Sophienhof" located in the pilot region, field tests for cultivation and harvest of game and fallow seeds are carried out. After harvesting and storage those materials are tested in the laboratories of the LUFA Nord-West on their suitability for biogas production.

A study for biomass potential in the pilot region has been commissioned. The focus will be on the actual energy production, energy demand now and in the future, the share of renewable energies in the energy supply and data on infrastructure, such as the economic structure and the inhabitants and data on the land use. Furthermore, detailed data on the development and structure of agriculture, the cultivated areas and the yield of crops and the animal husbandry will be assessed. To identify the influence of other stakeholders on agriculture, it is important to consider the regulations and directives, such as Natura 2000, the Water Framework Directive but also other aspects of nature and landscape protection and tourism.

Expected achievements

- Results on the biogas potential of fallow seed and game seed mixtures
- Study on biomass energy potential in the pilot region
- Calculation of profitability of selected supply chains
- Broad discussion about bioenergy with the stakeholders

Business optimization strategies

Few information about the production of biogas from these "new" materials exist. Despite the question if these inputs can be used for bioenergy purpose some research has to be done on the field of technique and machinery for treating those inputs. After the basic research is done potential investors need reliable economic calculations for their decision.

COASTAL ALGAE FOR ENERGY

Coastal algae for energy had been selected as a potential supply chain for Enercoast project by University Oldenburg. However this subject differs from all other supply chains included in Enercoast in two major and crucial aspects:

- a technology for economically viable and sustainable utilizing energy form algae is still under development (worldwide) and many serious obstacles remain open and unresolved;
- unlike other regions we actually do not have an abundant and predictable supply of algae for energy production in the Wadden Sea area.

Therefore, coastal algae supply chain is at present not a viable supply chain, and it will not become a functional supply chain within the Enercoast project time. However, the potential of marine bioenergy in the region will be realistically assessed.

Summary of literature review & evaluating of local conditions

Algae as a source of energy have been studied and explored for more than fifty years in several waves, corresponding usually with increased oil prices. During the last five years, the strongest wave of interest in energy utilization from algae has arisen, indicated by numerous research and business activities, and also organized conferences and dedicated societies. The vast majority of these activities have been focused on obtaining oil from microalgae in cultures.

Possible sources of algae for energy purposes are as follows:

- Natural growth – harvesting directly from nature (both micro- and macroalgae)
- Algae & macrophytes washed up on shore (beach-cast seaweed wrack)
- Cultures
    - On-shore tanks (microalgae)
    - Artificial ponds and raceways (microalgae)
    - Off-shore facilities (macroalgae)

Besides oil (biodiesel) as already mentioned , the list of metabolic products that can be further utilized as an energy source and that have been extracted from algae cultures/biomass include: hydrogen, ethanol, butanol, hydrogen peroxide, biogas (methane) or directly electricity (microbial fuel cells).

So far, despite many trials, only a handful of proposed approaches and technologies have proven viable and sustainable on a long time base, when scaled up beyond laboratory conditions. Very few cases make currently a notable economical profit. In other words, yields gained in economically meaningful scales do not usually match high expectations based on laboratory or small scale research.

However, at present there are many laboratories and small business worldwide working eagerly on improvements and development of feasible technologies. Most of the focus is on the algae for biofuel (biodiesel, bioethanol) process. It has been shown several times, that the companies exaggerate potential yields in order to attract investors. Also, because expectations are so highwith and many groups hoping to crack the code, the whole business is plagued by a lot of secrecy; unsuccessful trials are rarely published and therefore the same mistakes are repeated over and over, slowing down the progress.

Regarding algae–to-biogas technology, it has been shown by several authors that the yield of methane from algae lies somewhere between sludge and maize. However, the net economical profit is lower than these, given higher costs with culturing/harvesting and more complicated technological process required (salty biomass).

Natural growth

Macroalgae (mostly kelp – Laminaria sp.) have been harvested directly from shore areas for centuries, namely in California, Scotland, France (Brittany) and Norway as a source of soda, potash, iodine and alginates. As a result, kelp 'forests' declined in many places considerablywithnegativeconsequencesforsurroundingecosystem.Afeasibilitystudyalongthe Norwegian coast suggested that a five year cycle in harvesting on one spot was sustainable for kelp communities to recover (Christie et al., 1998).

The best method for obtaining energy from macroalgae is anaerobic digestion and by far the highest yield provide brown algae (Kelly & Dworjanyn, 2008). Kelp requires relatively clean sea and hard substrates to attach to, both factors which rules out this option from Wadden Sea area.

Also, the growth of microalgae has been limited by underwater irradiation in the Wadden Sea area (Loebl et al., 2009). There have been attempts to harvest microalgae both from freshwater and saltwater blooms by means of membranes or flocculation; however, no one has managed to accomplish this in economically feasible way. Currently, trials are ongoing in the Baltic Sea along Swedish and Finnish coast to harvest microalgae in the Spring period when algae blooms, when algae densities are very high and algae are concentrated close to surface. However, the shallow water in Wadden Sea coastal is way more turbid than the Baltic Sea.

Algae & seaweed washed up on shore (beach-cast seaweed wrack)

Macro algae wrack is seen on one hand as a nuisance by beach visitors/tourists and associated business and on the other hand as a valuable and important part of shore ecosystem by biologists (Colombini & Chelazzi, 2003; Rodil et al., 2008).

Recently, there have been several attempts to use the seaweed wrack as a source of biogas in anaerobic digesters in neighbouring areas (Schleswig-Holstein, Denmark) with rather questionable results – the yield of biomass does not seem to be sufficient to honour the effort (Schneider, 2008; Bech, 2009). However, in Japan a methane fermentation plant specifically for seaweed wrack has been successfully running for several years with input capacity of one ton/day (Kelly & Dworjanyn, 2008). Such facility requires guaranteed access of predictable amount of seaweed wrack and we do not have such conditions In the Wadden Sea Region, simply because there is not much seaweed grown locally.

Recently, idea proposal was made to utilize sea salad bycatch of local shrimp fishermen which is presently being dumped back to water. However, this source remains as yet very unclear, both in terms of quantities and potential economical feasibility of transporting and storing it on shore.

Cultures

Cultures of microalgae either in closed systems (photobioreactors) or open systems (ponds or raceways) are clearly more energy productive than any nature – based source. The difference is mainly due to significantly enhanced concentrations of CO2 bubbled into the algae culture, e.g. from a nearby factory (MacKay, 2009).

Certain algae or cyanobacteria have high lipid contents. Under proper conditions, these photosynthetic microorganisms can produce lipids for biodiesel with yields per unit area 100 times or more than possible with any plant system. In addition, the non-lipid biomass can be converted into methane, hydrogen, or electricity (Rittmann, 2008). Nevertheless, even for these high-tech controllable systems serious doubts exist if ever a long-time sustainability and profitability can be achieved (Waltz, 2009).

Cultures of macroalgae on frames anchored offshore are well established in terms of production and know-how along the coasts of Asia. The culturing is very labour intensive and harvested algae have so far been mostly been used for food, fertilizers or a source material for industrial products. Recently, along the coasts of North America and Europe (Norway, Scotland, Brittany), culturing of macroalgae for energy has been tested (Kelly & Dworjanyn, 2008). It seems however, that for algae in the sea to make a real difference, a country-sized harvesting area in the sea would be required (MacKay, 2009). In the Wadden Sea we are again facing a serious problem of high turbidity and also limitations by nature conservation authorities.

Status of coastal algae 'supply chain'

Status before project

- There has not been any business activity as yet, i.e. no supply chain based on algae exists
- There is no existing supply chain based on algae in any of the Enercoast regions either; so far all activities regarding utilizing algae to energy are in research and trial phase

Identified gaps in regional supply chains

- No knowledge on supply of sustainably produced sources of algae biomass
- Absence of proven and viable technology to be applied

Evaluation of supply chain options

- Mapping and evaluation of amount of seaweed wrack and possibly also algae by catch of shrimp fishermen is desirable
- Research on improvement of culturing options (polycultures of algae)

Evaluation of market options

- No market established yet

Selected indicators

- Amount of potentially utilisable algae biomass
- Economical feasibility of processing algae to energy locally

Involved stakeholders

- National Park Lower Saxony Wadden Sea authority
- Services taking care of beaches
- Shrimp fishermen

Challenges

- To obtain constant supply of sufficient algae biomass at a low price
- To keep in touch with research groups working on the subject and identify a feasible technology

Expected Enercoast intervention

- Calculate potentials of utilizing algae locally
- Contribute to improvement of culturing technology
- If progress in the field allows, prepare a plan for utilizing available algae biomass

Supply chains in Northumberland (England)

Anaerobic digestion is focus of the project in Northumberland

According to AEBIOM (2010) it is estimated that UK used 3.7 Mio. Tons of Oil Equivalents (Mtoe) biomasses for energy purposes in 2007, and the potential estimated for 2010 is 13.5 Mtoe and for 2020 the figure could reach 19 Mtoe.

Furthermore, AEBIOM (2010) states that the UK produces quite a lot of biogas from landfill and sewage sludge, but until 2007 no agriculturally based biogas at all. Most of Northumberland's[8] animal husbandry is based on free range grazing cattle and sheep, where no or little slurry/ manure is produced.
However, as the new Coalition Government has announced a 'huge increase' in anaerobic digestion in 2010, the industry is now set for radical growth - 2 plants should be built each week over the next 10 years - to meet the UK's renewable energy targets.

However, the UK is a leading country when talking about energy crops, such as willow and *Miscanthus* (Elephant grass). Between 14.000 and 24.000 ha are being cultivated with these crops in the UK in 2008. In fact, UK had about half of EU *Miscanthus* plantations, and a British company now provides Turn Key *Miscanthus* plantations all over Europe.

No specific figures are given for wood chips, but it is obvious that a part of the potential biomasses in 2010 could come from forested areas.

8. Northumberland is a ceremonial county and unitary district in the North East of England, Being on the border of England and Scotland, Northumberland has been the site of many battles. The county is noted for its undeveloped landscape of high moorland, a favourite with landscape painters, and now largely protected as a National Park. Northumberland is the most sparsely populated county in England, with only 62 people per square kilometre

Northumberland College and the Northumberland Renewable Energies Group (NREG) stakeholder consultations carried out by NREG initially identified that the project should focus on two supply chains

- Wood chip and
- Anaerobic Digestion (Biogas)

Further to our initial investigations relating to supply chain analysis in Anaerobic Digestion (Biogas) and Wood Chips we have re-visited a number of the initial interviewees to establish what movements have taken place since our initial meeting. We have concluded that the initial results should be our ultimate aim.

Northumberland College is currently in discussions with Northumberland County Council to adopt Earth Balance - a 220 Acre site which was developed in partnership with the local authorities, local business and the community to show how natural resources can be sustained, jobs created and energy harvested without waste or pollution. It is hoped that this additional site coupled with our agricultural site at Kirkley Hall we will be able to meet the outstanding demands of the Enercoast project as well as drive the renewable energy agenda within Northumberland.

SUPPLY CHAIN ANALYSIS

Due to a number of problems within our institution, the progress and the planned research has been limited until early May 2010. A number of reports from various partner organisations have been read to highlight numerous challenges within the supply chains of both wood chip and anaerobic digestion (biogas) within the North East.

Anaerobic digestion (biogas) supply chain analysis

So far, the supply chain analysis for anaerobic digestion (Biogas) can be presented in schematic form:

Process stage 1: Materials supply			
Targets	Enablers	Indicators	Indicator units
Find competitive alternatives to complement input materials	Identify agencies which deal with inputs	How many agencies identified	Material available (tons per annum)
	Research (e.g. marine algae)	Level of knowledge	Level no.
Promote sustainable farming	Workshops with farmers	How many farmers participate	Number of motivated participants ready to make changes
Achieve sustainable supply	Promote local integration to produce supply network	Cooperative and mutually beneficial integration of local suppliers	Number of participants involved
Ensure social acceptance	Identify life style priorities through workshops	Agree on parameters to promote change into farming habits	Number of key indicators for accepting supply change
Ensure crop diversity	dentify suitable alternative crops	Positive attitude to crop diversity	List of crops which are accepted by farmers

Process stage 2: Logistics (Find competitive alternatives to current logistics)			
Targets	Enablers	Indicators	Indicator units
Reduce transport loads	Transport survey	Identify methods to reduce trips	Number of trips reduced
Ensure social acceptance	Involvement of farmers and neighbors	Collaborative problem solving approach	Number of complaints (% reduced)
Reduce environmental impacts (emissions, noise)	Identify load volumes	Invest in cooperative tanks	Levels of env. impacts reduced
Optimize intermediate storage	Seasonal delivery survey	Identify just-in-time delivery potential	Streamlined volume in comparison to capacity of digestion (tonnage/day)
Segregation of municipal waste for food waste feed stock	Educate communities what can be used	Adequate recycling facilities / separators for household waste	Number of areas taking on this recycling scheme

Process stage 3: Production (Promote sustainable energy production)			
Targets	Enablers	Indicators	Indicator units
Minimize operational costs	Cost analysis	Identify potential for improvement (by KPIs)	Greater % of cost reduced
Assure high materials efficiency	Identify operations parameters	Fine tune parameters	Greater % of output yields
Reduce health risks	Awareness raising of H&S plans	Key danger areas	Less accidents
Minimize environmental impact	Ranking of environmental impacts	Action plans according to ranking	Reduced incidents of spillage, run-offs, leaks
	Effective plant design	New plant designs checked / accredited for approval	Rating system of plant effectiveness or number of plants under going approval
Ensure social acceptance	Collaborative approach to management targets	Acceptance levels	% acceptance (questionnaire)
Provide and secure employment	Profitability check	Check by AD equipment designer and business analysts	Number of long-term employments

Process stage 4: Grid distribution			
Targets	Targets Enablers	Indicators	Indicator units
Guarantee grid access	Accessibility of DNO (= utility) staff	Reduce response time, Plain English talking, Affordable costs	Gt grid connection agreement
Increase grid reliability	Improve rural grid	Investment in rural grid	< Number of grid fluctuations
Reduce grid losses	Improve rural grid	Investment in rural grid	<% of grid losses
Reduce grid costs	Put back into local infrastructure	Part power plant or local industries (e.g. CHP)	% costs reduced
	Negotiation with consultants	Find affordable consultants	<% of grid connection costs and distribution charges
Reduce health risks	Grid technology	Effects on health	No. of persons at risk

Process stage 5: Usage. A: Electricity B: Heat C : Fuel D: (Compounds) Combined			
Targets	Enablers	Indicators	Indicator units
Use renewable energy efficiently	Technology and infrastructure	Energy performance and efficiency	£/kwh
Promote sustainable regional energy self-sufficiency	Ignore nationwide ideas and identify regional sustainable profile	sustainability	Number of regional variance in contrast to nationwide ideas

Wood chips biomass supply chain analysis

So far, the supply chain analysis for wood chips can be presented in schematic form:

Process stage 1: Materials supply			
Targets	Enablers	Indicators	Indicator units
Find competitive alternatives to complement woodchip	One-stop shop wood fuel distribution centres – i.e. Northumbrian Woodfuels	PR for RDPE wood supply chain	Map showing percentage of area witinin 15 miles of the hub
Promote sustainable farming	More Links in Environment and Farming (LEAF) Demonstration Farms and Members	Acceptability of Integrated Crop Management / Integrated Farm Management	No's of members of LEAF
Ensure social acceptance.	Workshops for citizens	Persuasion of rural citizens	No's attending educational events
Ensure crop diversity	Natural England's Schemes	Change of attitude of Land Manager	Percentage monitored for diversity
Ensure woodchip Accreditation	Ignite Course by Northwoods	Percentage of wood sold with Accreditation	Percentage monitored for Accreditation

Process stage 2: logistics (Find competitive alternatives to current logistics)			
Targets	Enablers	Indicators	Indicator units
Reduce transport loads	Increase Intelligence	What is the number of road miles/ load	Look of trend lines
Ensure social acceptance	Educate the general public	Events to inform stake holder	Target versus actual achievement
Reduce environmental impacts (emmissions, noise)	Invest in equipment	Grant funding set up monitoring and advice	Set up Environmental Assessment monitoring of top 10 locations
Optimize intermediate storage	Grants for storage	Number of new stores	Monitor avenue wood miles

Process stage 3: Production (Promote sustainable energy production)			
Targets	Enablers	Indicators	Indicator units
Minimize operational costs	Amalgamate and advise	Numbers of businesses and turnover	Efficiency targets hit
Assure high materials efficiency	Maximum efficiency with equipment and storage	Set targets for percentages within specification	Real figures from main producers. Percentages within specification
Reduce health risks	Health and safety events and advice	Hold events across the area	% increasing or decreasing risks (survey of awareness of risks)
Minimize environmental impact	Set up audit criteria	Similar to LEAF audit	Check scoring
Ensure social acceptance	Set out guidance	Carry out survey	over 50% of people satisfied
Provide and secure employment	Maximise business opportunity	Grant scheme through Business Enterprise North East (BENE)	Measure GVA figures

Process stage 4: Grid distribution			
Targets	Enablers	Indicators	Indicator units
Guarantee grid access	Funding for connection	Schemes given access	% given access
Increase grid reliability	Best Technical appraisal	Look at failures	Measure downtime
Reduce grid losses	Technical expertise	Measures losses	% lost
Reduce impact on landscape	Careful planning of locations	Ask residents about intrusion	<% dissatisfied
Reduce grid costs	Location planning	Cost per connection	£/MW as a percentage of average
Reduce health risks	Think health and safety from beginning	Measure incidents	Numbers of accidents and near misses

Process stage 5: Usage A: Electricity B:Heat C : Fuel D:(Compounds) Combined			
Targets	Enablers	Indicators	Indicator units
Use renewable energy efficiently	Best practice EU and beyond	Compare to best practice	League table of schemes RE efficiency
Promote sustainable regional energy self-sufficiency	Micro-renewables and co-firing	Business and citizen awareness	Percentage who know and are in favour

DISCUSSION OF SUPPLY CHAIN GAPS AND OPTIONS

For this analysis of the supply chains we have identified numerous gaps.

Identified gaps in regional supply chains

- The geographical location of Northumberland and its consequential lack of support from the Government office,
- A significant amount of additional money needs to be found to make research more effective. This will prove more difficult in light of the new government and the need to reduce government spending in light of the financial crisis,
- A number of issues relating to the lack of schemes within the area could be tied generally to the embryonic stage of the industry,
- No major manufacturer of biomass energy systems exists within the UK
- Consequently this increases the installation costs of either system (Wood/biogas)

However, some systems are currently in the development stage at the minute but the larger AD systems have been ongoing for some 18 months.

The above gaps have highlighted the lack of trained installers, which creates additional issues relating to quality, cost, safety, guarantee etc., all of which we need to address in modern procurement policies within the UK.

The lack of large scale plants and systems has to a certain degree hindered the uptake of potential growers/distributers.

Other issues or challenges to increase the biomass to energy supply include

- limited resource of organic animal waste due to free range farming.
- the local climatic conditions prohibits viable/economical growth of *Miscanthus* and
- the initiation of short rotation coppice is not being considered by farmers due to the long turn around on capital investment.

Other issues relating to the barriers can be seen as:

- Not enough bespoke consultants within this area of specialism to give unbiased advice
- No specific show cases to illustrate the benefits of either strand of Biomass.

However, two local organisations are currently building anaerobic digesters for research purposes, these should be commissioned late 2010, and Enercoast is currently working with both. In addition, some signs of small wood supply chains are growing to the west of the county through initiatives driven by Northwoods and a local grant scheme.

Supply chain mobilization in Ryfylke (Norway)

Greenhouses at Finnøy

BACKGROUND

Initially, it is necessary to bear in mind the energy system in Norway with its supply of electricity from waterfalls at low costs. In addition, the oil production and natural gas in the North Sea keep energy prices low. This provides a very special situation for the introduction of the concept of sustainable supply chain analysis for bioenergy in the region. While it is difficult to apply the 'full' analysis for yet unproven supply chains, the concept and approach of supply chain analysis may be very useful for the establishment of two new supply chains in the region.

Several municipalities in Ryfylke have electrical power concessions providing 10 % of the total produced electricity in their area for their local use. This means that they can sell up to 10% electricity, but not more than what is used in the municipality. A lot of smaller municipalities are not able to use 10% of the local concessions, and the remaining part will fall to the county. The result is that if a small municipality with electrical power concession introduces energy saving activities, then they can potentially loose economic income. This have been a barrier in the project, and finally The Ministry of Petroleum and Energy solved this problem in March 2010.

Bioenergy has not been in real focus until recently in Norway. It is expected that the frame conditions will be changed, as the minister of energy has now placed renewable energy on the agenda in Norway. At present waterfalls are not easy to extend due to landscape restrictions, economy etc. and therefore, the minister has introduced a new agenda with biogas, wind turbines, solar energy etc.

A new regional plan for energy and climate in Rogaland county[9] has been published with the following major goals:

- Rogaland will produce 4 TWh new renewable energy in 2020
- Rogaland will reduce its energy consumption by 20 % in 2020
- Rogaland will in 2020 reduce climatic pollution by 600.000 tonn CO2-equivalents

The potential of biogas and bioenergy from manure in Rogaland county is estimated around 500 GWh. The targets for bioenergy in Rogaland county:

- A production of 0,35 TWh biogas in Rogaland in 2020
- The use of energy in agriculture shall be reduced by 10% per unit by 2020

In this context, Enercoast takes off in almost 'virgin land' for bioenergy in Ryfylke. Ryfylke is an area with many small islands, high mountains and deep fjords, where logistics will be challenging for many bioenergy solutions. The selected supply chains to be worked with in Enercoast are the following:

- Finnøy Bioenergy supply chain and
- Bioenergy for new settlements – Taumarka as

FINNØY BIOENERGY SUPPLY CHAIN

Finnøy[10] Bioenergy is a planned biogas plant (independent shareholder company established in 2009) based on manure and other organic wastes in a relatively intensively cultivated part of Norway with animal husbandry and tomato green houses.

However, before the start of Enercoast, only very preliminary ideas and smallscale units (only woodchips) had been worked on in Ryfylke without traditions and only with a limited market for woodchips production and use. This means that quite some time is needed to give birth to the idea, to create local support, to establish the organisation and the financial basis for a biogas production and finally the market for use of the biogas.

Potential rawmaterials for biogas in Ryfylke

- 892 farms in 2007
- Average farm size; 12,1 ha arable land
- 312 dairy farms with 17 cows per farm
- Breeding sows; 1.600, Fattening pigs; 28.000
- Hens; 326.000, Chickens; 700.000
- Waste from tomato production, households and fish industry
- Waste /mud from salmon breeding
    - from closing nets in saltwater – no technology available for this today.
    - From (smolt cultivation in) freshwater - maybe 1000 ton in Rogaland perr year

9. Formerly called "Stavanger amt", Rogaland 'fylke' is located on the southwestern coast of Norway. Rogaland has historically been divided into four regions: Dalane, Jæren, Nord Rogaland, and Ryfylke. There are 26 'kommuner' (municipalities) in Rogaland

10. Finnøy is a municipality in Rogaland county, Norway. It is an island community located in Boknafjorden, 13 nautical miles (24 km) north of Stavanger. Finnøy is an agricultural community dominated by dairy, meat, poultry, and fish farming products, with strong horticultural traditions, mainly greenhouse production of tomatoes, and some tourism.

Potential energy from biogas will have to compete in a market with traditional electricity or oil/gas from the North Sea. In Norway there is no tradition using biogas, due to rather low priced electricity. The reasoning behind the Finnøy biogas supply chain is manifold:

- to solve problems with excess nutrient losses (leaching of nitrate and evaporation of ammonia) from the islands (to comply with the Nitrate Directive and Waterframe Directive) through
    - better distribution of manure nutrients (spreading areas for manure) and/or
    - optimize the use of manure nutrients from degasified slurry for cultivation
- the use of energy and nutrients from the large quantity of organic waste from the green houses,
- to solve the energy needs of the local community and at the same time comply with CO_2 reduction targets,
- meet the market by producing "green tomatoes" (i.e. tomatoes from bioenergy heated green houses),
- to secure and provide job creation and settlement.

Plenty of woody resources are available in Norway

Biogas can provide heat and CO2 for tomato cultivation

Bioenergy for heating

Identified challenges

For the supply chain analysis, two major challenges have been identified in Enercoast

- The **economic frame conditions**
- The **logistics for biomass to energy** is quite challenging within a group of islands.

The challenge is firstly to get a supply chain organised on the main island in Finnøy, where manure and wastes from the fields and green houses can be used for biogas production. The aim is

- to replace fossil energy for heating and lightening of the tomato greenhouses with locally produced biogas.
- to improve the distribution and use of the manure nutrients for agricultural crop production and thereby reduce the leaching of nutrients.
- to create new economic income for farmers and tomato producers.

However, a period of time is needed to motivate people and change their focus on energy, and finally it is a question of economy for the farmer and the energy user. It is a matter of constructing a chain and of building a market for biogas.

The key indicators

Sustainability indicators	Key performance indicators	Gaps
economic	Materials supply; quantity and prices	unsure – no contracts
social	Positive image	not tackled
Economic - ecological	The use of the degasified slurry	R&D* – not tackled
economic	Prices (gas, heat, electricity)	unsure

* Process for scientific research started

The key stakeholders

- The farmers (livestock and greenhouse, they are also the main shareholders)
- Investors – different types of engineering companies and some private investors
- The municipality of Finnøy (politicians, local people, neighbours)

The major gaps

Still numerous gaps exist until the supply chain for biogas becomes realised on Finnøy. Most of these elements are part of the needed business plan for the concept:

- The establishment of the supply of biomass is still not organised. Contracts between farmers and the biogas plant have to settle quantities, timing and price
- The logistics of transportation of the agricultural wastes on and between islands should be investigated – both from an ecological and economic point of view
- The question of creating a positive image for biogas in Finnøy should be focussed on
- The correct and optimum use of degasified slurry to reduce leaching and optimize crop uptake should be investigated
- The resulting prize for a produced m3 of biogas has to be calculated and the corre sponding prize for heat and electricity can be calculated, depending on the solution and deployment of the energy

The main target for 2010

- Business plan for biogas
- Decision of investment based on business plan

Discussion

Generally in Norway there is poor scientific and practical knowledge about bioenergy and especially about biogas based on materials from the agricultural sector. However, a knowledge development process has started and it is likely that University of Stavanger, International Research Institute of Stavanger and Bioforsk (a national R&D institute under the Norwegian Ministry of Agriculture) will become qualified on these issues in a few years. In addition, Ryfylke is involved in a bioenergy-knowhow project at college level (Strand Videregående Skole).

There are three key indicators, so far underestimated by Finnøy Bioenergy: materials supply, social acceptance and the end-use of energy. The concept of sustainable supply chain analysis can be used to clarify some of these issues.

The social acceptance is a challenge which the project almost neglected. This challenge should never be underestimated and some farmers are at present not very satisfied with the information and process on the biogas project. The Norwegian Enercoast partner has communicated this challenge to the project leader of Finnøy Bioenergy and they will take action.

Conflicts between the stakeholders are another issue. It has not yet been thoroughly discussed and agreed upon whether the biogas be used for one or more greenhouses. Alliances between some farmers and greenhouse owners have been created and therefore this conflict may influence the supply of manure as well. In addition Finnøy Bioenergy has not yet contracted enough manure, nor contracted enough waste from the fish industry and greenhouses.

These challenges should be met in the biogas business plan, as well as the communication challenges. The economy of a biogas plant is very much dependent on the use and sale of the produced energy – for heating, for electricity and heating, or for gas only (via an independent grid or the established "Lyse-grid"). This will probably be clarified this year.

A new solution can be that they will build a biogas plant to supply municipal buildings. However, in that case they will be confronted with a new problem of using the CO2 emitted. The reason for this is that when the energy supply is connected to municipal buildings, it will be more difficult to obtain agreements with greenhouses that need CO2 for increased plant growth. Then the greenhouses will not be a part of the supply chain.

BIOENERGY FOR NEW SETTLEMENTS – TAUMARKA AS

In order to produce more bioenergy in Ryfylke, other potential projects have been identified and analysed in the Enercoast project. Wood waste in all the communities is the next step after our intensive ongoing case study "Bioenergy in Ryfylke".

The initial intention was to generate an overview and a registration of opportunities and establish new renewable energy as an important task in an area with the highest power production from waterfalls in Norway. There is a high production of wood suitable for woodchips, but the logistics within the area are challenging. Forestry should provide an income for the owners and the companies who want to produce and sell energy. The main goal for this pilot project is to build the whole woodchips supply chain, from the forest to the user of energy.

However, the local mill (Fiskå mølle), which processes grains, also has a lot of shells from oats (husks), which can be used for heating and/or electricity production with a calculated potential of about 20 GWh per year. Technical knowledge is needed and a business plan needs to be developed before decisions can be taken on this potential alternative bioenergy resource to be used.

A specific plan has been developed to make an infrastructure for heating 130 houses in a new area at Tau in Strand - phase 1. Taumarka is an independent project organized as a shareholding company. The role of Enercoast is to introduce the Supply Chain Analysis, to motivate and connect to relevant projects, transfer of know-how and to have regulars meetings with the project parallel to the process of developing the Sustainable Supply Chain Analysis.

The first phase is to supply bioenergy (at least 40% from renewables, excluding hydropower) to building phase 1, consisting of 130 living units. The idea is to base the energy supply on woodchips. The grid will have a connection point which will make it possible to enter hot water from other sources as husk and biogas. There will be possibilities to connect the grid further to some municipal buildings in Tau, some houses and office buildings and to the college Strand VGS.

The key indicators

Sustainability indicators	Key performance indicators	Gaps
	Economical support from Enova SF* (application posted January 2010)	No answer
economical	Technology and price for "shell from oats" and burning (phase 2 or 3)(20 GWh per year)	R&D
economical - social	Cost per KWh; what is acceptable for the customer?	missing

*Enova SF is owned by the Ministry of Petroleum and Energy

The key stakeholders

- Taumarka as (a limited company/the project owner)
- The suppliers of woodchips
- The settlers/ buyers of energy

Identified gaps

- The support from Enova SF has now been clarified, and this is a key issue to establish the economic basis for the establishment of the supply chain.
- Because of the scale, the framework conditions, the economic challenges and the need for a backup it will be built to deliver energy with North Sea gas, but not more than maximum five years. The transition to bioenergy will then take place within five years. Hopefully this transition can be earlier too, depending on the economic situation and the number of customers. It will be an important work in the project to shorten the time for transformation to bioenergy, and to look for good solutions for that.
- The use of agricultural residues (e.g. husks) may need research, but probably this knowledge exists in other Enercoast partner regions
- The pricing of bioenergy needs analysis: What are the customers willing to pay for bio energy in district heating?
- There is a need for a plan for energy and climate in Strand municipality. This plan can secure forecasting and solve current gaps in the supply chain. It may be helpful to avoid the need for using North Sea gas in prospective projects, and hopefully reduce the time for doing the transition to bioenergy at Taumarka.

The main target for 2010

- Building phase no 1 started

Discussion

There are no major unsolved issues within the Taumarka project. This is a new settlement project – a total of 700 living units are to be built within the next 10 – 12 years. The project relevance for Enercoast is the target of 40% renewable energy (excluding hydro energy) for the Taumarka project.

This will probably be solved by using woodchips. However, the local potential alternative bioenergy source of oat husks has to be analysed. Knowledge is needed before decisions can be taken on this issue. In addition, a wind turbine at Taumarka could possibly one day become part of future solutions.

Another pertinent question is whether it will be easy to sell these new houses, under the premise of using woodchips for energy, i.e. what will be the acceptable energy-price to pay for the buyer? The answer has not been found yet but the project promoters and we both believe that this will not be a problem.

NEW SUPPLY CHAIN – ÅRDAL BIO

A potential new supply chain has been identified in Ryfylke and will be briefly introduced here.

Årdal Bio is a biogas pilot project with economic support from Innovation Norway formed by local farmers. The plan is to use waste from fish farms, manure from cattle and maybe peel from turnips. They are going to supply a factory in Årdal with hot water.

Critical factors:

- A Biomass input inventory is needed including larger areas
- Uncertainty about transport and gridlines
- There is a challenge to get contracts with the fish farmers to deliver the salmon/fish waste.
- Nothing has been done yet about the information to the local community
- Research – there is uncertainty about the mixing of manure and fish waste

BUSINESS OPTIMIZATION STRATEGIES FOR THE SELECTED SUPPLY CHAINS

In the Ryfylke cases, the supply chains are in need of detailed business plans before the decisions for establishment can be taken. Årdal Bio has similar challenges as Finnøy Bio. It may be useful to let those two projects work together to solve their common challenges.

Although the three pilot projects are independent units, the concept of supply chain analysis can be introduced and used in the development of the business plans. With the supply chain view on the first draft of a business plan, decisions can be made on how to optimize the business plan. However, a basic business plan needs to be developed first to be able to optimize the value chain.

Transnational evaluation of regional supply chain options

The intention of the Enercoast approach is to introduce the concept of Sustainable Bioenergy Supply Chain Analysis and to contribute to finding common solutions to common problems. The concept has been implemented to address different assignments in the participating regions. The overall picture of the analysed supply chains reveals that the challenges are often linked to national/regional frame conditions and traditions. Although the challenge of introducing more bioenergy has reached global dimensions due to the expected climate changes, the solutions found will probably not be identical. Rather they will differ regionally due to numerous political and natural framework conditions.

In Ryfylke and Northumberland and for the algae in Lower Saxony, no supply chains exist at this point in time. However, the analysis shows that the Sustainable Bioenergy Supply Chain Analysis method can contribute to organising and clarifying innovative ideas prior to building the needed supply chains on the pathway to establish the supply chains. The general idea of Sustainable Bioenergy Supply Chain Analysis is that before any new supply chains are introduced they should be proven sustainable in the specific region.

The Enercoast activities may actually end up concluding that a particular supply chain is not sustainable – and therefore should not be promoted - in a particular region due, for example, to a specific social factor or due to the economic frame conditions. On the other hand, a partial supply chain in one region may continue in another, e.g. woodchips from Norway sold in Denmark could become a reality.

In Fyrbodal, Central Denmark Region and Lower Saxony, the well established supply chains can indeed benefit from this Sustainable Bioenergy Supply Chain approach giving rise to new questions and new ways of tackling the challenges. In all three regions, the political climate is very beneficial for biogas and this is indeed the right time to develop alternative pathways. In all regions the focus on alternative biomasses to feed into the biogas plants is a key issue and we can definitely learn from the approaches of the neighbouring regions. Interestingly, in all three regions, inventories of potential biomass for biogas is being made using different tools, statistics and approaches reflecting the different traditions and availability of data.

Also, regionally different approaches to biogas deployment can inspire cross-regional transfer and adoption. Biogas for district heating in Denmark may not be the only solution in the future and the upgrading for fuel or for the gas grid as used in Fyrbodal and Lower Saxony is very inspiring and merits the attention of other regions .

In conclusion, this report is not the answer to all the challenges addresses, but could provide important knowledge from stakeholders in the five regions towards new emerging bioenergy businesses to achieve the common goal of reducing the use of fossil fuels.

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A key element of the Enercoast strategy is to apply the concept of Sustainable Bioenergy Supply Chain Analysis to a diverse range of bioenergy initiatives across the North Sea and thereby detect their hidden potential.

This interim report features the analyses conducted in five North Sea regions, outlines the stakeholder communities involved, pinpoints relevant economic, ecological and social indicators and identifies current gaps in the featured supply chains. The findings from the starting point for intervention strategies to promote bioenergy potential in the North Sea Region.

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