SOLRØDBIOGAS

– CONCEPTION, PROJECT DEVELOPMENT AND REALISATION

Solrød Biogas – conception, project development and realisation
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INTRODUCTION

The aim of this publication is to provide the reader with an understanding of the challenges in planning a biogas plant and the important experiences gained from successfully going from an initial idea to the actual construction of the Solrød Biogas plant in Solrød Municipality. The publication is written within the framework of the EU initiative – *Mobilizing Local Energy Investments (MLEI)* which has provided financing to the preparation of the project. This publication primarily focuses on the project development phase where the core decisions, tendering, and planning efforts have been made. However, a recapitulation of the activities undergone before and an insight into the efforts still ahead are also included.

> The success of the project is for the greater part based on this interesting public-private cooperation between the municipality, suppliers, outlets, and research institutions. At the same time, the project has attracted people with various kinds of expertise essential in order to manage a project of this nature.
>
> *– explains Niels Hörup, Mayor in Solrød Municipality and Chairman of the Board in Solrød Biogas A/S.*

The Solrød biogas project is based on a collective objective to establish a biogas plant with great benefits for all parties involved. Particularly, this close cooperation between the parties is key to the realization of the project and to meeting the requirements in order to obtain project subsidies from partners such as the EU - MLEI project, Region Zealand, and Growth Forum Zealand. Also, the coming together of numerous skills has been pivotal to the success of the project, and Roskilde University in particular has provided essential input to the project development.

Why did this idea emerge?

The idea to build a biogas plant in Solrød came mainly from two concerns; an odour problem for the community stemming from seaweed fouling the beach, and the municipality wishing to take action in the climate challenge by producing green energy. From this the idea developed, and very soon it became clear that local industries also had challenges with finding proper outlets for their by-products, why they found great interest in the plans. This triggered a project that could benefit from numerous actors and interests.

KEY RECOMMENDATIONS

General organization

It can be advantageous if developments and optimisations of a biogas plant are organised as public-private cooperation in the early phases, i.e. in the initial and the project development phases. Such cooperation contributes to: 1) more openness to different interests, 2) better projects, and 3) the chance of being more innovative in a field in need of innovation – the seaweed issue being a good example.

The initial phase

A feasibility study is an advantage in order to uncover possibilities and issues. The feasibility study deals with all essential issues in relation to establishing a biogas plant, and the result of the study in Solrød was that there would be no serious obstacles to establishing a biogas plant. Following this, the uncovered key issues and possibilities were setting an agenda for the development phase.

Project development phase

Firstly, it is essential to involve politicians and collaborative partners during the process. By involving politicians and collaborative partners during the process, especially when establishing the company, as illustrated above, the ownership of the project is spread out to a wider group of people. This has ensured an indispensable political commitment and a significant prioritizing of the project.

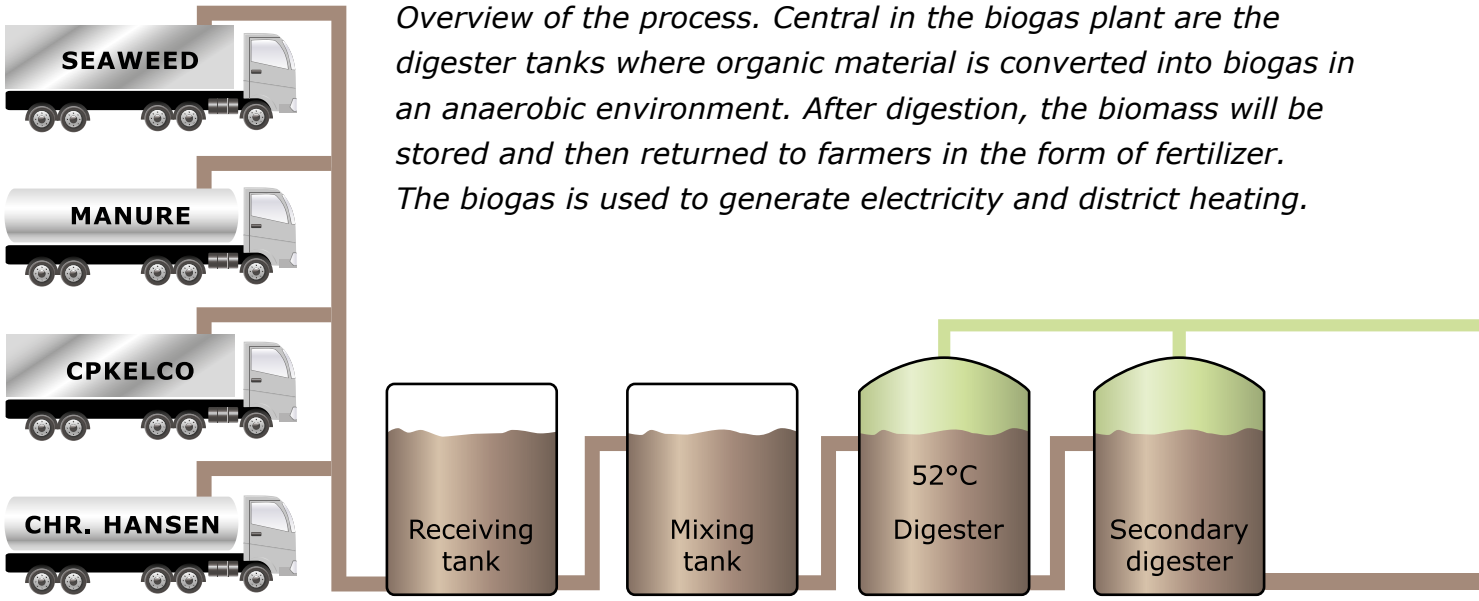
Secondly, it is a substantial advantage to organize the development process in such a way that stakeholders can be directly involved. The focus is on integrated design process and goal-oriented project development. To ensure stakeholders' involvement, it is important to focus on multilateral benefits of the biogas plant and develop these multifaceted benefits in an interaction with the various stakeholders. It is a good idea with a coherent project document because it ensures internal consistency in the development process of the biogas plant and creates the optimal relationship between the different topics in the planning process.

Thirdly, it is vital to recognize that regulatory approvals and permits take time and have a built-in hierarchy. Therefore, focus should be on planning for decision-making, public hearings, technical pre-hearings, etc. to include stakeholders at an early stage and avert unnecessary duplication. At the same time incorporating object-oriented planning in this work will ensure state of the art permits and locational requirements in line with what is in the best interest of the biogas plant.

Fourthly, it is highly recommendable to buy in technical, financial, and legal expertise especially when preparing the call for tender for construction of the biogas plant and when designing contracts. In this, cross-level reflection in respect to overall supply and purchase of biomass and biogas is necessary in order to secure a reasonable business and financing plan. It is conducive from the beginning to involve suppliers and outlets in designing contracts. Attraction of possible cooperation partners is helped by information campaigns and materials with specifications on contents of products, expected regulations, etc., and by engaging local (agricultural) consultants with a view to playing an active part in "selling" the concept.

Collaborative partners at the turning of the first sod event, September 2014.
Photo: Peter Jarvad

FACTS ABOUT SOLRØD BIOGAS



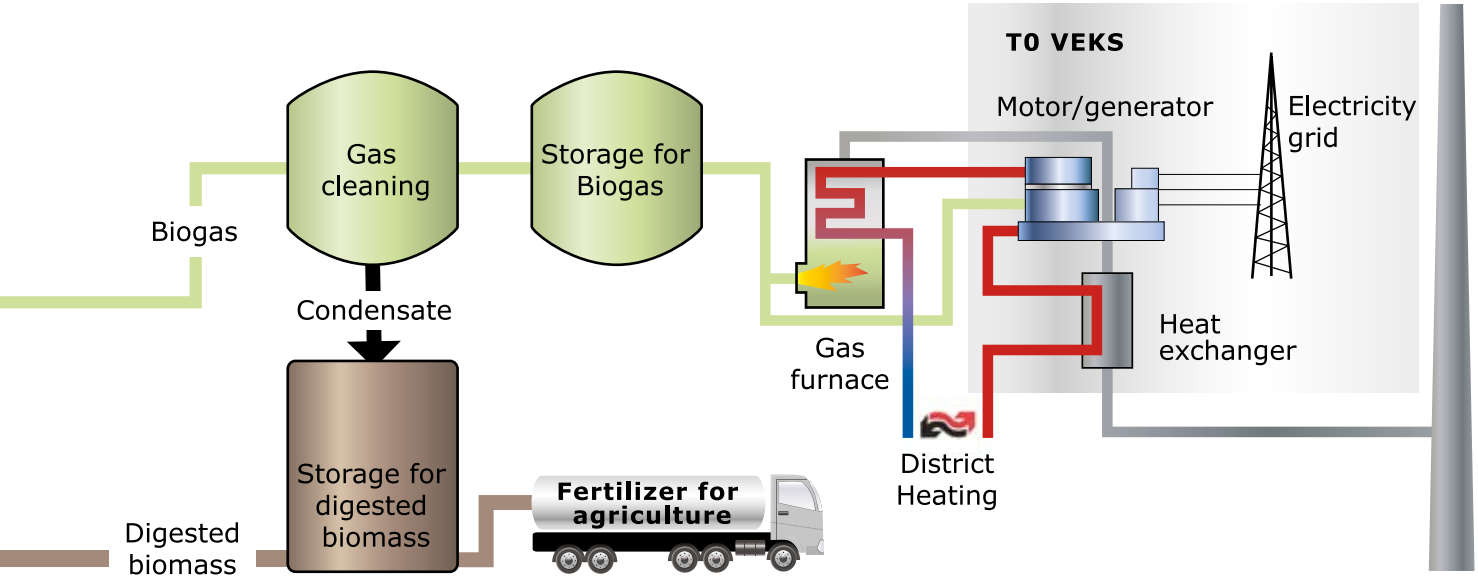
Overview of the process. Central in the biogas plant are the digester tanks where organic material is converted into biogas in an anaerobic environment. After digestion, the biomass will be stored and then returned to farmers in the form of fertilizer. The biogas is used to generate electricity and district heating.

The figure above gives an overview of the process from residue input to digested biomass and energy output.

The biogas plant is designed for a raw material capacity of 200,000 tons. The produced biogas is used in a large gas engine in order to produce power and heat. The power will be sold to the electricity network and the heat will be used in the comprehensive district heating system organised by the regional district heating transmission company VEKS (Vestegnens Kraftvarmeselskab I/S), which is owned by 12 stakeholders (municipalities).

The energy production of the biogas plant and the expected reduction of greenhouse gas emissions are incorporated into Solrød Municipality's Sustainable Energy Action Plan (SEAP) under the Covenant of Mayors.

> The biogas plant will contribute to a better marine environment, a reduction of CO_2 emissions, and less odour nuisances – all in all: win, win, win …
>
> *Director of VEKS, Lars Gullev*



Treated manure	53,200 tons / year
Treated biomass from CPKelco	79,400 tons / year
Treated Biomass from Chr. Hansen	60,000 tons / year
Treated biomass from beach cleaning	7,400 tons / year
Digested biomass to agriculture	192,000 tons/year
Gas production (methane)	6 million m^3/year
Electricity production	23 GWh / year
District Heating	28 GWh year
Investment	DKK 85 million (ex. CHP plant)
Annual revenues	DKK 23 million

KEY BENEFITS – SOLRØD BIOGAS

The biogas plant has a number of benefits for the parties involved. Some benefits are very tangible such as reductions of transport costs, improved fertilizer, and zero carbon energy, whereas others are less physical but nonetheless still important. These include a rise in environmental awareness among citizens and politicians in the municipality and a chance for the parties involved to upgrade their environmental profile externally.

In the citizens' review from 2014 by the administration in Solrød Municipality, many citizens express their satisfaction with the removal of seaweed from the beaches and with the efforts to produce green energy from the seaweed.

In general the key benefits of the plant include:

60 GWH/ YEAR

Production of approx. 60 GWh/ year of renewable energy from sustainable sources which reduces dependency on fossil fuel and foreign energy sources.

A solution to a waste problem. Reduction of costs and insecurity connected to the transport and marketing of residues from the industry involved.

Contributing to solve problems with aquatic pollution. Delivery of 72% of the current 2015 target of the EU Water Framework Directive for nitrogen reduction in Køge Bay and more than 100% delivery of the reduction targets for phosphorus levels. Using cast seaweed will remove 62 tons of nitrogen/year and 9 tons of phosphorus/year.

Removes **62** tons **NITROGEN/ YEAR**

Reduction of **ODOURS** from the **BEACH**

Knowledge-sharing regarding potential for improving sea water quality and recreational use of the maritime environment by collecting cast seaweed.

Biomass treated in the biogas plant (digested biomass) can be used as biological fertilizer, which is a more efficient fertilizer than other non-treated biological fertilizers, and as substitute of chemical fertilizers on farmland in the area.

Overall reduction of greenhouse gases at approx. 40,100 tons of CO_2 - annually. The biogas plant will ensure a greenhouse gas reduction equivalent to approx. 50% of the total municipal reduction target for 2025.

40,100 TONS OF CO_2 REDUCED ANUALLY

Reduced leaching of nitrogen and phosphorus to the aquatic environment by using digested biomass as a more efficient organic fertilizer.

104 PEOPLE EMPLOYED

Local employment. Put together it is estimated that the construction will employ 90 people, the operation of the plant 4 people, and the transport to and from the plant 10 people, whereof the main part is employed locally.

KEY MILESTONES – SOLRØD BIOGAS

After a long but focused course of development, the company Solrød Biogas A/S was formed in May 28, 2014. All contracts paving the way for establishing the plant were concluded on June 19, 2014, and the first sod of the construction phase was turned on September 17, 2014.

> It all started with an odour problem due to seaweed fouling the beach. Inspired by the traditional use of seaweed in agriculture, we began considering seaweed a resource. A couple of experts believed the seaweed to have gas potential. Subsequently, the project took off and we realised that by cooperating with the industry we were able to contribute to increasing the reutilisation and to generate a gas product which - to companies such as VEKS - can be converted into a major power and heat potential.

Niels Hörup summarizes the development up until this stage in short terms.

How does the idea become real?

The heat plan, the climate plan, and the feasibility study have contributed to embed the biogas plant in the municipal council and in its political decisions. They have also contributed to disseminating information about the plans by means of publications and the local media to a large part of the public.

Milestone		Year
Climate challenge + seaweed challenge		
Municipal heat plan		2008
Municipal climate plan		2009
New ideas – from seaweed to gas		
Preliminary agreement with CP Kelco		
Preliminary studies – support from Growth Forum Zealand		2010
Environmental Impact Assessment		2011
Renewed agreement with CP Kelco		
Preliminary agreement with VEKS		
Financing from the EU	June	2012
Negotiations with Chr. Hansen and the agricultural sector		2013
Turnkey contractor tendering	August	
Selection of turnkey contractor	May	2014
Establishment of Solrød Biogas A/S	May	
Final agreements with Bigadan (contractor), CP Kelco, VEKS, Chr. Hansen, and the agricultural sector	June	
Preparation on site	August	
The first sod of the construction phase	September	
Plant completed	Summer	2015
Test driving and commercial operation	Autumn	

PROJECT ORGANIZATION IN PHASES
– WHAT'S AHEAD OF US?

All in all, it will take seven years from the idea of a biogas plant was formed in Solrød until the plant is completed and ready for production. This period includes everything from the very first ideas of local biogas in the municipal heat planning in 2008 and eventually commercial operation of the plant in 2015.

Three phases

Typically, the development of a plant will be divided into phases – from an uncertain foundation to an increasingly stable foundation. It is not always a continuous process; sometimes, issues that have been addressed at an early stage have to be readdressed in a new context. The overall activities can be divided into three main phases:

- *Phase 1 – Initiation:* The feasibility study provides an answer to whether it is possible to establish the plant in question. The study typically consists of resource, technical, economic, and environmental assessments.
- *Phase 2 – Project development:* Specification of design options (coherent project document). Permits and regulatory approvals, contracts with suppliers and takers, development of the formal ownership, etc.
- *Phase 3 – Building and construction activities:* Completion of the construction. Permits and regulatory approvals (planning permissions), construction of plant, construction inspection, initialisation, guarantees, etc.

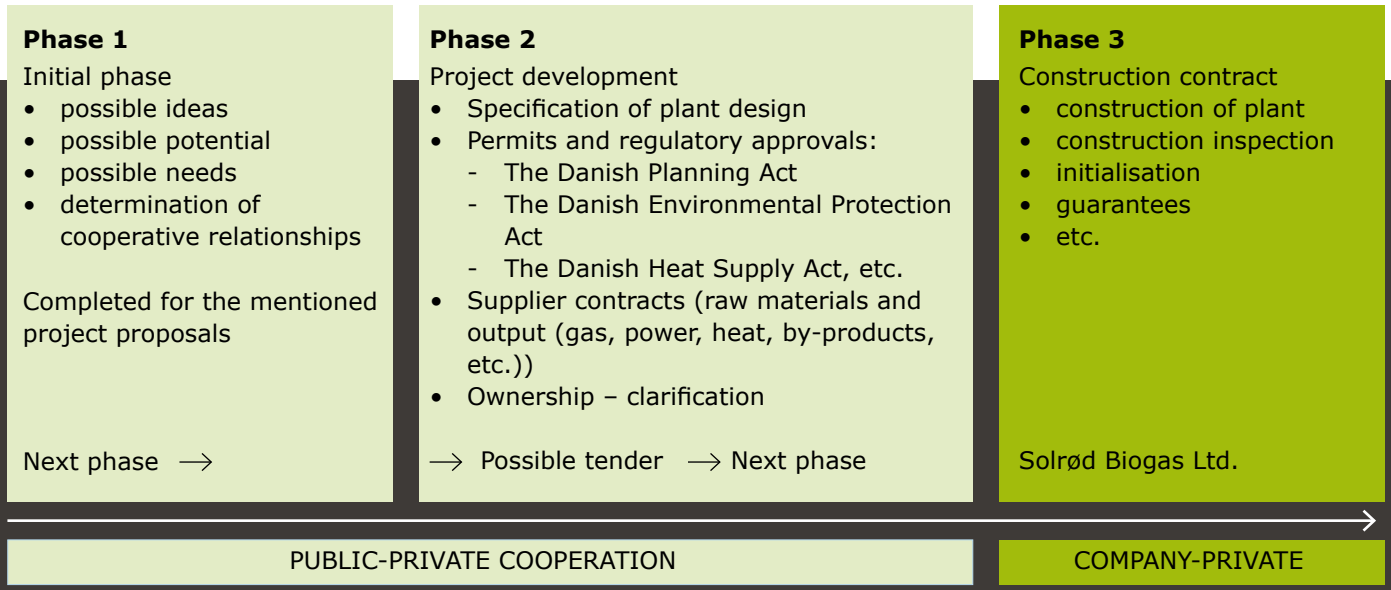
The *first* phase typically consists of initial plans and the feasibility study. The second phase includes development of the project, and characteristically of this phase it focuses on decision-making, dealing with a number of specific issues, optimising the plant concept, drawing up contracts and agreements, and clarifying ownership and related legal issues.

Once such decisions have been made and dealt with, contracts can be made, the construction can be commenced, and the plant can be initialised. The three main phases are listed below.

Generally, it is assessed that only few of the many obvious possibilities for establishing renewable energy plants will be realised unless municipalities actively cooperate with local initiative groups, etc. Consequently, phases 1 and 2 are listed as public-private cooperation.

In principle, it is only possible to determine whether a project is realistic or not when all the

Project development



Phases in the development of the Solrød Municipality biogas project

regulatory work has been made, all approvals received, the contract outline is known, etc. Only then, it is clear whether all costs generated during the project development process will be covered by the future plant. This is the stage involving the most obstacles to establishing a biogas plant and other major renewable energy plants.

The difficulties in establishing biogas plants and other renewable energy plants are that a considerable sum must be spent *before* it is certain that the plant can actually be established. There is no simple rule of thumb as to the amount of costs of phases 1 and 2 compared with phase 3. In relation to Solrød Biogas, the costs of phases 1 and 2 amount to approx. 10% of the total construction cost.

That it is uncertain early in the process whether a biogas plant can be established or not, can be remedied in several ways. One way of dealing with it is to cut costs of the development work in phase 2. However, by doing so there is a risk that the plant is not optimally developed.

There are examples of biogas plants whose development work has been insufficient, resulting in the plant inflicting financial losses on the local authorities. Such negative lessons learned have often caused a public negative attitude towards biogas technology and the opportunities represented by this technology.

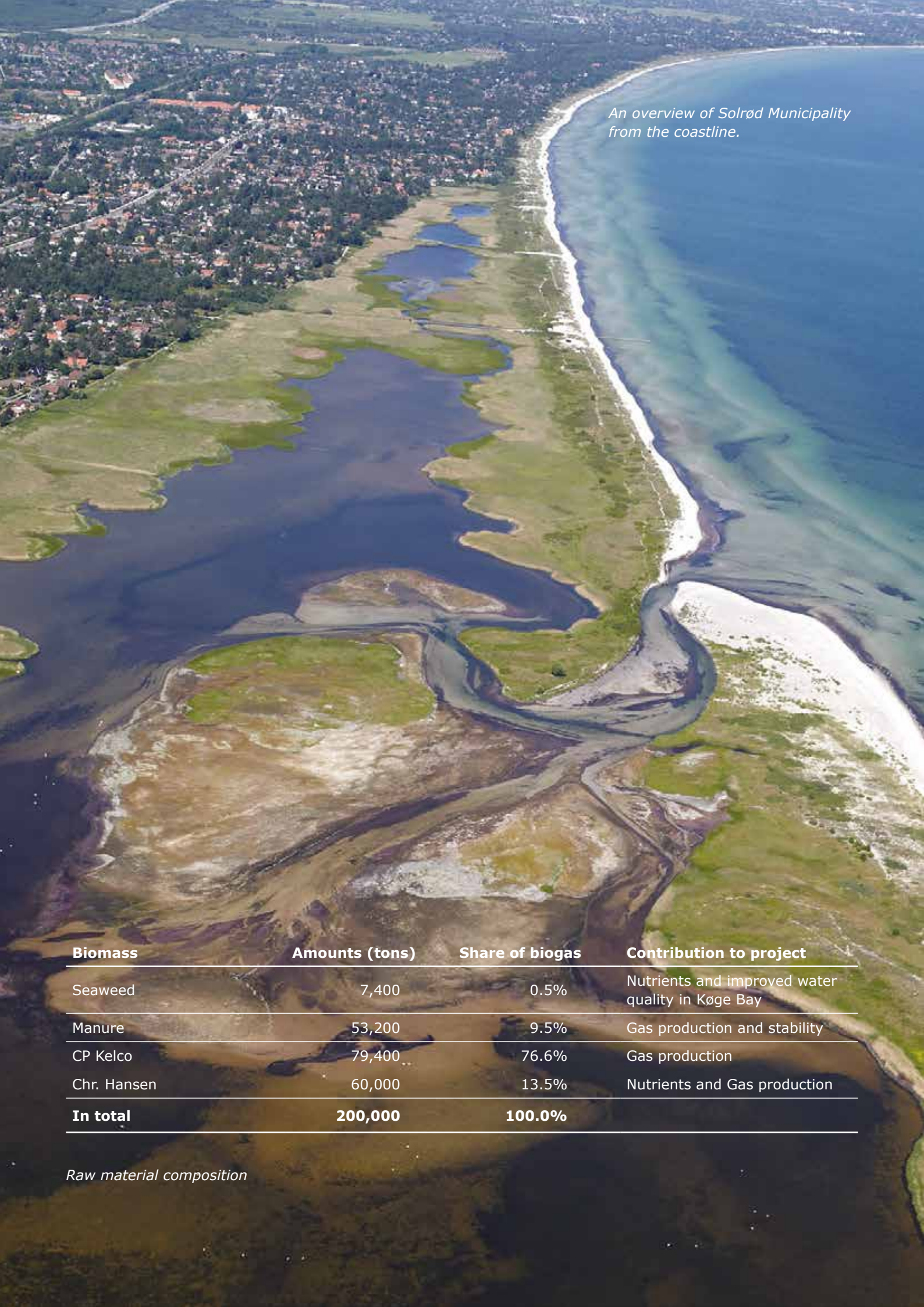
The alternative, which has been the objective of the development work of the Solrød Biogas plant, is thorough feasibility studies, risk minimising by digestion experiments with the plant's raw material base, detailed surveys of consequences of different technology options, detailed environmental impact assessments, economic optimisation analyses, etc. This alternative – thorough feasibility studies – will particularly be advantageous in public-private cooperation, as chances of taking various interests and preconditions into consideration will improve through such cooperation.

The local authority – the municipality – is interested in thorough feasibility studies. If such studies are not made, the local community and the municipality risk incurring losses. Thorough feasibility studies increase the chances of project completion and of the plant being able to reimburse the local authorities or municipality the development costs from phases 1 and 2.

LESSONS LEARNED

It could be advantageous if developments and optimisations of a biogas plant were organised as public-private cooperation in the early phases (phases 1 and 2).

Such cooperation contributes to:
1) more openness to different interests,
2) better projects, and 3) the chance of being more innovative in a field in need of innovation – the seaweed issue being a good example.



An overview of Solrød Municipality from the coastline.

Biomass	Amounts (tons)	Share of biogas	Contribution to project
Seaweed	7,400	0.5%	Nutrients and improved water quality in Køge Bay
Manure	53,200	9.5%	Gas production and stability
CP Kelco	79,400	76.6%	Gas production
Chr. Hansen	60,000	13.5%	Nutrients and Gas production
In total	**200,000**	**100.0%**	

Raw material composition

PHASE 1 – INITIATION
– IS IT FEASIBLE?

As mentioned, a feasibility study of a possible future biogas plant was conducted in 2010. The objective of the study was to map the available raw materials, measure the chemical composition and value of the raw materials for biogas production, assess the methods of seaweed collection, find a location for the plant, make technical/financial assessments, and make an environmental assessment focusing on reducing the emission of greenhouse gases.

The feasibility study was a kind of analysis of options. The results of the study were accounted for in "The Use of Seaweed and By-products for Production of Biogas, Phase 1: Feasibility study".

The overall conclusion of the feasibility study was that 1) it would be realistic to establish a biogas plant with a sound economy, and that 2) considerable environmental advantages could be achieved by doing so. Several plant concepts were pointed out, and they primarily differed in how the produced biogas was to be used.

The main features of the feasibility study are briefly recapitulated as the study can provide an insight into which issues were managed in phase 1 and which issues had to be brought into phase 2.

Raw materials and biogas

In the feasibility study it was important to map relevant local raw materials that could be used in the biogas production. Washed up seaweed in Køge Bay had already been pointed out as a potential raw material. This washed up seaweed was collected during beach cleaning activities in the municipalities of Solrød, Greve, and Køge.

Additionally, the quantity of manure from local farms was studied as well as organic by-products from the local industry, etc. It became evident that the most relevant materials were by-products from pectin and carrageenan production from CP Kelco, seaweed from Køge Bay, and manure from pig and cattle farms. Various scenarios were outlined in relation to the composition of the raw material, including varying quantities of manure.

The suitability of these materials for biogas production was further assessed by measuring their chemical composition (solid matter content, nutrients, and heavy metals, etc.) and by measuring their "methane potential" generating an idea of how much biogas can be produced.

The method currently used to collect seaweed on the beach results in too much sand in the collected seaweed, and this turned out to be one of the challenges identified in this phase. It was emphasised that the collection techniques should be improved and further developed, and that methods for sorting out sand at the biogas plant should be further examined.

An estimate of the plant's gas production was based on the measuring of the methane potential of the various raw materials and the compilation of the available quantities. The annual biogas production was assessed to be between 5.4-6.3 million m3 of methane, depending on the raw material composition. The majority of the expected gas production is based on the pectin by-product as it is present in major quantities and has a relatively high content of convertible organic dry matter. However, earlier tests had shown that the pectin by-product alone would not work as raw material, but that by mixing the pectin by-product with manure, a satisfactory biogas production was obtainable.

Location, operating economy, and greenhouse gases

The feasibility study listed two suitable locations for the biogas plant. One of these locations was in the open land in Solrød Municipality – southeast of Jersie By at Åmarken. The other suitable location was adjacent to CP Kelco in Køge Municipality.

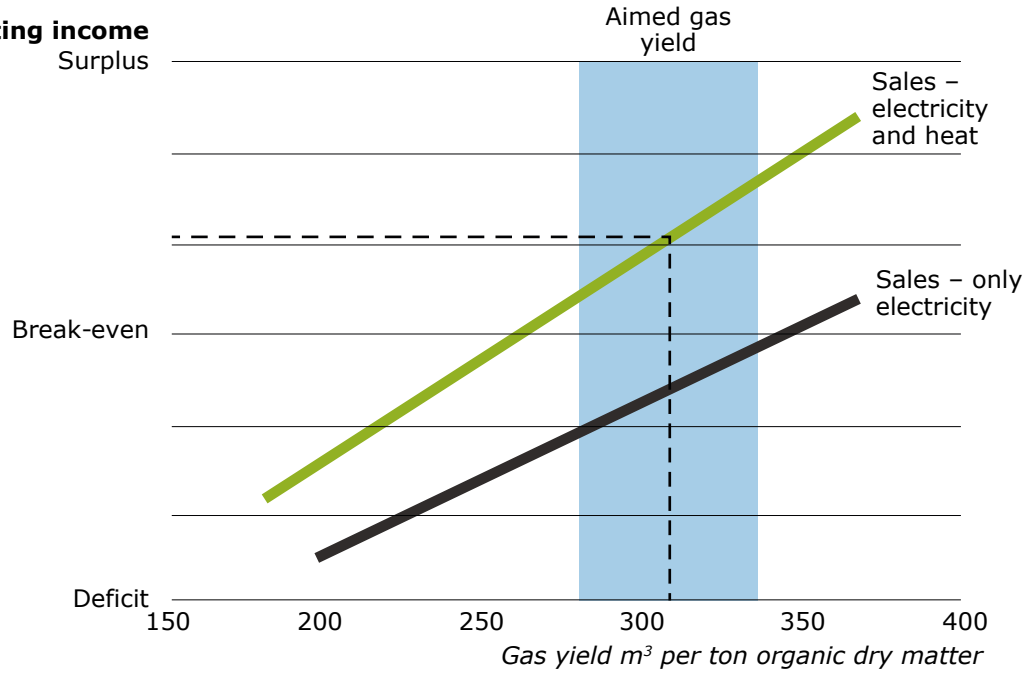
The study concluded that due to the current energy infrastructure in the two areas, it would be most suitable to use the biogas for combined heat and power if the location of the plant was to be in Solrød Municipality, whereas a location close to CP Kelco would make it advantageous to use the biogas for process heat at CP Kelco or to upgrade the gas for use in the natural gas network.

The construction and operating economy was estimated for both options based on industry experience and inquiries with construction consultants. The total construction and development costs were assessed to be somewhere between approx. DKK 78.5 million and DKK 93.5 million, depending on the plant concept.

Break-even revenue at different gas yields

Operating budget (pre-tax) at different gas yields

The figure shows two things: 1) That the profitability of the plant is a direct consequence of the gas yield. 2) That it is vital to design the plant so that all products can be sold, i.e. if gas is to be used to produce combined heat and power both electricity and heat should be sold. If the waste heat cannot be sold the profitability will be affected negatively and this can only be compensated through ensuring a higher gas yield.



The environmental impact of the plant was assessed based on the expected raw material composition and the recorded biogas production. It was concluded that the biogas plant would be able to contribute to a reduction of the emission of greenhouse gases in the range of 25,000 tons to 40,500 tons annually (converted into CO_2 equivalents). The size of the reduction depends on the plant concept. The largest reduction will be obtainable from a combined heat and power production, whereas upgrading the gas to natural gas quality will result in a comparatively smaller reduction.

The reduction of greenhouse gases will primarily be generated by replacing fossil fuels, but it will also be the result of a change in the handling of manure and a reduction of methane which would otherwise be generated by anaerobic (oxygen free) decomposition of the seaweed on the beach. In the calculation an increased emission of greenhouse gases from elements such as the power consumption of and transport in relation to the biogas plant was deducted.

Thereby, the realisation of the biogas plant was found to be an essential contribution to meeting Solrød Municipality's objective for reducing the emission of greenhouse gases. Besides the reduction of the emission of greenhouse gases, increased collection and removal of washed up seaweed from Køge Bay will also generate a considerable reduction of nutrients and thereby contribute to an improved water quality. Chemical analyses of the seaweed compared with recorded seaweed quantities showed that approx. 62 tons of nitrogen (N) and approx. 9 tons of phosphorus (P) can be removed annually.

Due to the positive prospects about the plant's economy and environmental impact, Solrød City Council decided to proceed with realising the biogas plant project.

LESSONS LEARNED

A feasibility study is an advantage in order to uncover possibilities and issues. The feasibility study has dealt with all essential issues in relation to establishing a biogas plant, and the result of the study was that there would be no serious obstacles to establishing a biogas plant. Following this, the uncovered key issues and possibilities were setting an agenda for the development phase.

Beach cleaning and collection of seaweed at Solrød Beach

Reduction of greenhouse gas emissions – assessment undertaken in phase 1

	Amount/year	Reduction of greenhouse gas (CO_2 equivalents)
Replacement of fossil fuels		
Biogas based electricity production	24.500 MWh	19.800 tons
Biogas based heat production	28.600 MWh	6.200 tons
Reduction of greenhouse gas		
Reduction of nitrous oxide and methane		3.100 tons
Reduction of methane from seaweed and waste		11.900 tons
Greenhouse gas from use of fossil fuels		
Electricity consumption at the plant	910 MWh	- 420 tons
Use of diesel in transport	45 m^3 diesel	- 125 tons
In total		**40.500 tons**

Niels Hörup, Mayor in Solrød Municipality and chairman of the board in Solrød Biogas A/S turns the first sod at the Solrød Biogas plant.
Photo: Peter Jarvad

PHASE 2 – PROJECT DEVELOPMENT
– LET'S GET TO WORK!

This is the core phase. Here lies hard work and many hours with the constant uncertainty that the project may be turned down anyway. The principle activities in this phase are:

- Intensified political decision making.
- Continued stakeholder mobilization and especially thorough coordination.
- Regulatory approvals.
- Procurement.
- Contract design and more detailed economical assessments.

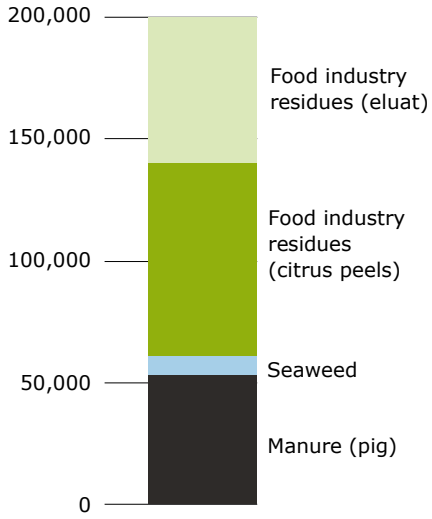
Two things are important to bear in mind when running through these activities:

1) The activities mentioned play a large part in phase 2, but all are not exclusively found in one phase of the project. Generally these activities shall be seen as continuous and circular processes as one small change in a contract or in the localization of the plant has great effect on whether the economy is right, whether new political decisions or approvals are necessary, or how the negotiations with contractors etc. will proceed.

2) As the activities are interconnected and continuous it is important to organize the project to facilitate this interaction.

The raw materials of the biogas plant

200.000 tons in total



Visualization of the plant, Summer 2014.

POLITICAL DECISION MAKING

A wide range of political decisions is to be carried out when planning a biogas plant. An important part of these decisions in Solrød was made in the course of establishing a limited company to manage the construction and non-technical operation of the plant.

The company Solrød Biogas A/S was established on 28 May, 2014 with Solrød Municipality as the sole shareholder. The company objectives are stated in the company documents as follows: "to establish and run a biogas plant, etc. to produce energy for collective heat supply using raw materials supporting the fulfilment of climate, environmental, and waste disposal purposes and purposes related hereto. The company can solve the tasks in collaboration with public authorities and companies as well as private companies."

The contribution of Solrød Municipality in the company is partly a contribution in cash and partly a contribution in kind. The contribution in kind is the value of the development work, which was a precondition for the establishing of the biogas production that is to be carried out by the company. Remuneration is paid to Solrød Municipality in shares.

The company´s board of directors consists of five board members from Solrød Municipality including the mayor, Niels Hörup, who has been appointed chairman of the board. The board has engaged a director for the day-to-day management of the company.

A main issue seen in a municipal context is in the course of the process to present the city council with a timeline showing the important decisions to be taken and secure ownership by including the council throughout the process.

The figure below illustrates the different stages of the decision making process relating to the establishment of corporate form and ownership.

Stage 1: Primarily, a decision had to be taken on the design concept of the plant, forming the basis for the biogas plant and the company formation. The selection of the design concept of the plant had different environmental, legal, and financial consequences, as it had to be decided whether to go with the combined heat and power model or the upgrading model (natural gas). The selection was naturally of importance to the final set-up of the project, but also to know which partners to approach

STAGE 1	STAGE 2	STAGE 3	STAGE 4
December, 2012	**April, 2013**	**June, 2013**	**April, 2014**
Selection of company type	**Preparation of company establishment**	**Preparation of company documents**	**Establishment of Solrød Biogas A/S**
The biogas company is run as a private limited company	Objectives, owners, and capital base	Articles of association, option agreement, and owner agreement for Solrød Biogas A/S	Final decision
(December 17, 2012)	(April 29, 2013)	(June 17, 2013)	(April 28, 2014)

Stages of the decision making process. The dates of the stages indicate the involvement of the city council and approval of important decisions in respect to the on-going process.

for negotiations. The negotiating partners also had to be informed of the municipality´s expected position in the company.

Stage 2: Based on the preliminary considerations the city council had to make the decision about the company formation and the main conditions that were to be in force in the future, including shareholders and the most important relations between the shareholders. Before the company formation, it was necessary to determine the company objectives, i.e. the type of activities carried out by the company and the purpose hereof.

Stage 3: Based on the determined operating purpose and the agreed structure, articles of association, rules of procedure for the board of directors, etc. were prepared. As Solrød Municipality is the sole shareholder an actual owner, agreement was not prepared, but the future possibility of additional shareholders was discussed in a positive manner. At the city council meeting in June, 2013 the city council had to make the final decision concerning owner agreement and preparation of memorandum of association for Solrød Biogas A/S.

Stage 4: The establishment of the company Solrød Biogas A/S was only a formality and took place by signing the memorandum of association and simultaneous passing of the company´s articles of association. The chairman and board members were elected at an unofficial general assembly. At the company formation the auditor had also prepared an opening balance and an assessment report as basis for the company´s contribution in kind.

LESSONS LEARNED

Firstly, it is essential to involve politicians and collaborative partners during the process. By involving politicians and collaborative partners during the process, especially when establishing the company, as illustrated above, the ownership of the project is spread out to a wider group of people. This has ensured an indispensable political commitment and a significant prioritizing of the project. In Solrød the political involvement has been possible due to a relatively flat organizational structure in the municipality, where both the administrative management and the political management are continuously updated on the project status and are involved in the discussions with the project group.

Secondly, it is recommended to hold thematic days or similar, where the political management is thoroughly prepared for decision taking. Before each important decision in the city council, especially concerning the company formation, the project group made sure to give the politicians the possibility to get answers to many of their questions directly from the experts involved.

STAKEHOLDER MOBILIZATION AND COORDINATION

> We have created the basis of a project with high probability of coming into being in cooperation between knowledge centres, municipal players, and industry. A project of such category may very well be difficult to implement without this very interesting private-public cooperation
>
> *says Plant Director of CP Kelco, Jørn Stryger, at the beginning of the project.*

There is no doubt that the success of the Solrød Biogas project is due to a highly engaged and dedicated partnership between municipal politicians, administration, industry, agriculture, and knowledge institutions.

The reason for this successful stakeholder mobilization, the continued highly valuable coordination between these, and the ability to do this in a coherent manner can be understood by studying three different elements, which Solrød Biogas has been working with.

1. Integrated design process

Over the past couple of years it has been debated how plants are best developed and designed. The debate has typically been between what is known as the *linear design process* and what is known as the *integrated design process.*

If the developer chooses the linear design process, the developer leaves the project development to a number of equal-ranking experts. In certain cases it may be a very effective process with a rational decision-making process, and often stakeholders are not effectively involved in this process as there is no room for them. The alternative – the integrated design process – is a number of design teams working together on specific issues during the development of the project.

Organising the development process according to such a pattern will greatly ensure insight into and influence on the development of the project. These *principles* have been used as a basis for arranging the organisation responsible for the development assignments in phase 2.

The five "design teams" or working groups all are characterised by having extensive contact with the directly involved stakeholders and other stakeholders besides the members of the working groups.

The constuction site, August 2014.

Organization of Solrød Biogas development process

City Council/Mayor of Solrød Municipality (SM)

Steering Committee

- Managing director of SM
- Technical manager of SM
- Managing director of VEKS
- Plant manager of CP Kelco
- Project owner of the Solrød Biogas project
- Project manager of the Solrød Biogas project

Project Management Committee

- Project owner of the Solrød Biogas project
- Project manager of the Solrød Biogas project

Interdisciplinary Committee

- Project owner of the Solrød Biogas project
- Project manager of the Solrød Biogas project
- Researcher from RUC
- Technical advisor

Working Groups

Permits and Regulatory Approvals Group

Coordinator: Project owner of the Solrød Biogas project

Tender Group

Coordinator: Technical advisor

Seaweed Group

Coordinator: Project manager of the Solrød Biogas project

Agricultural Group

Coordinator: Project owner of the Solrød Biogas project

Economy and Company Group

Coordinator: Researcher from RUC

The mayor represented Solrød City Council in the biogas project. The mayor was engaged throughout the project and took part in decisive negotiations with the parties involved as well as with contributors. Moreover, the mayor addressed the project at public meetings and various public events dealing with renewable energy and biogas. The mayor, and subsequently the city council, approved all significant issues related to the establishment of Solrød Biogas A/S, i.e. applications for project grants, permits and regulatory approvals, company formation, financial basis, etc., as well as granted resources for realising the project. The chairman of the steering committee continuously informed the mayor on the progress of the project.

The steering committee consisted of the most significant stakeholders in the realisation of the project, i.e. the project owner, in this case Solrød Municipality, the plant manager of CP Kelco, which will be the main supplier of biomass, and the managing director of VEKS, the exclusive customer of the biogas. The managing director, the technical manager, the project manager, and the appointed project owner represented Solrød Municipality, with the managing director serving as steering committee chairman. The main task of the steering committee was to make the major decisions related to the project, monitor the progress of the project, be instrumental in embedding the project firmly in the relevant organisations, and submit recommendations to the mayor, to Solrød City Council, and to the boards of CP Kelco and VEKS. Principally, the steering committee met every three months, but out-of-schedule meetings were held if required.

The project management committee consisted of a project owner and a project manager. The head of the Department for Nature and Environment in Solrød Municipality was appointed project owner, whereas a recently employed energy and environmental planner in Solrød Municipality was appointed project manager. From the very outset, it was decided to place the project management responsibility within the municipality itself; partly with a view to benefiting from the lessons learned throughout the project, thus providing the organisation qualified expertise, and partly with a view to being in a position to consult the political level as the project progressed. Direct access to the political level was secured by introducing a manager from the municipal administration into the project management committee.

The project management committee was responsible for ensuring that the agreements and decisions made by the steering committee and the interdisciplinary committee were materialised and that the coordinators of the individual working groups solved their tasks. Thus, the project owner and the project manager were jointly in charge of the day-to-day running of the project. The project management committee met on a daily basis and participated in all steering committee and interdisciplinary committee meetings. Moreover, the project management committee was responsible for creating a team spirit in the interdisciplinary committee based on the objectives of the project generating motivation and enthusiasm among the project participants and stakeholders.

The constuction site, September 2014.

The interdisciplinary committee was set up with the sole purpose of supporting the project management committee owing to the complex nature of the project. The committee's work included initiating the necessary studies/enquiries, preparing the required basis for decision-making, drafting cooperation agreements with various parties to the project, and acting as problem solvers. The committee comprised the project manager, the project owner, a researcher from Roskilde University (RUC), and the technical advisor. A legal advisor, an agricultural consultant, an accountant, a technician from CP Kelco and a technician from Solrød district heating company joined the committee on an ad-hoc basis. The permanent members of the committee also served as coordinators vis-à-vis the individual working groups.

The interdisciplinary committee was not a project group per se, and consequently, no actual project work was done in this committee. The committee was responsible for:

- Generating a comprehensive view of the project.
- Determining the guidelines for drafting the project document.
- Preparing the time schedule with milestones.
- Securing coordination between the working groups vis-à-vis overlapping tasks.
- Achieving cross-project acceptance of the work done in the working groups.
- Assuring the quality of the work done in the working groups.
- Submitting recommendations to the steering committee.

The committee met regularly every two weeks. The permanent members of the committee were cc'd on all correspondence relevant to the project in order to keeping them informed on the progress of the work of the steering committee, working groups, and project management committee. Full insight into the correspondence also meant that the permanent members of the interdisciplinary committee were in a position to make adjustments in the event they discovered unfavourable developments in the project.

The working groups were set up due to the size and complexity of the project. The members of the working groups were selected/ appointed in consideration of the qualifications required for the specific tasks at hand. The coordinators of the groups were selected among the permanent members of the interdisciplinary committee. Overall, the task of the working groups was to ensure the realisation of the mandate given to each group.

2. Objective-oriented plant development

The form of the organisation ensures influence of the various stakeholders, but what do they have influence on? In the development of the biogas plant several simultaneous objectives corresponding to the interests of the stakeholders have been dealt with. Not only does the plant provide energy, it must also solve a waste and odour issue at Solrød Strand. One of the objectives of establishing the biogas plant is to achieve *multilateral advantages.*

The development work and prioritisation in phase 2 are

The constuction site, October 2014.

best characterised as objective-oriented development work. The plant, choice of raw material, technical preferences, permits, and regulatory approvals, etc. have taken their starting point in a number of objectives which everyone – not least the stakeholders who each have wanted the project to meet one or more of the objectives – wants to be met. Naturally, it is a precondition that the construction and operating economy of the plant must be sound.

The multilateral advantages and relevant objectives can be summed up as follows:

- *Renewable energy:* Production of renewable energy and thus the contribution to the changeover of the energy system, which enjoys national and local political support.
- *Obnoxious smell:* Contribute to solving the odour issues stemming from washed up seaweed and brown algae on Solrød beach by using seaweed and brown algae in the biogas plant.
- *Climate efforts:* The use of by-products and seaweed for the production and use of power and heat from the biogas production replace fossil fuel and contribute to reducing the emission of greenhouse gases.
- *Plant nutrients:* The removal of seaweed from the coast contributes to reducing the pollution of the aquatic environment. By removing seaweed and brown algae it will almost be possible to reduce the nitrogen and phosphorous quantities corresponding to the objectives of the first water environment action plan, stemming from the EU Water Framework Directive.
- *Manure:* The raw material composition of the biogas plant and the optimisation of this composition mean that a well-qualified natural fertilizer is developed. A product that can replace fossil produced fertilizers.
- *Waste issues:* The design and the raw material composition of the plant also contribute to solving a waste issue, including cheaper and more environmentally safe waste handling in the participating industrial companies.
- *Conversion of district heating:* The objective of the district heating company VEKS is to generate fossil free heat supply no later than in the year 2025. The use of the excess heat from the gas engine of the biogas plant will contribute towards this conversion.

The multilateral advantages have helped generate support of and interest in the development and establishing the plant with a significant number of stakeholders.

3. Project Document

The realization of the biogas plant requires - as shown by the previous - the strong involvement of the various interested parties or stakeholders that are directly and indirectly related to the establishment of the biogas plant. This is the main idea of the integrated design process. One possible negative effect could be uncertainty about how the system develops during the Phase 2-process.

In order to avoid negative effects of combining the many stakeholders, a *coherent project document* can be developed. The coherent project document aims to

The constuction site, October 2014.
Photo: Rune Paamand

ensure a continuous update of the plans for the establishment of the plant.

The project document consists of a series of linked spreadsheets containing technical, economic, and environmental data. The project document is developed so that changes in the assumptions can be easily incorporated and consequences assessed. For example, changes in composition of raw materials or quantities, finance, grants, etc. The document also provides essential data for regulatory approval (the municipal supplement local plan, environmental impact assessment, environmental approval, and project approval by the Heat Supply Act) and for the ongoing financial analysis, for example, evaluation and analysis of investment requirements and ongoing review of the business case.

An example may illustrate the usefulness of a coherent project document. Through the development of the Solrød Biogas plant in phase 2, it became clear that the original composition of raw materials would cause problems with nitrogen in the residual product to be used on the fields. The nitrogen content was too small to ensure the interest of the farmers who were supposed to use the residual product.

The solution of this problem was a supply of additional quantities of raw materials so that the plant should be designed for 200,000 tons. This led to a change in the design, in the gas volume, and in other technical parts of the project, but it also led to a change in relation to regulatory approvals, economic, environmental data, etc. Changes in one field - induced by a group of stakeholders, the farmers - led to a number of other changes, which, however, quickly could be documented and assessed through the comprehensive project document.

LESSONS LEARNED

Firstly: It is a substantial advantage to organize the development process in such a way that stakeholders can be directly involved. The focus is integrated design process.

Secondly: To ensure stakeholders' involvement, it is important to focus on multilateral benefits of the biogas plant and develop these multifaceted benefits in an interaction with the various stakeholders. The focus is goal-oriented plant development.

Thirdly: It is a good idea with a coherent project document because it ensures internal consistency in the development process of the biogas plant. The focus is to continuously create the optimal relationship between the different topics in the planning process.

The constuction site, November 2014.

REGULATORY APPROVALS

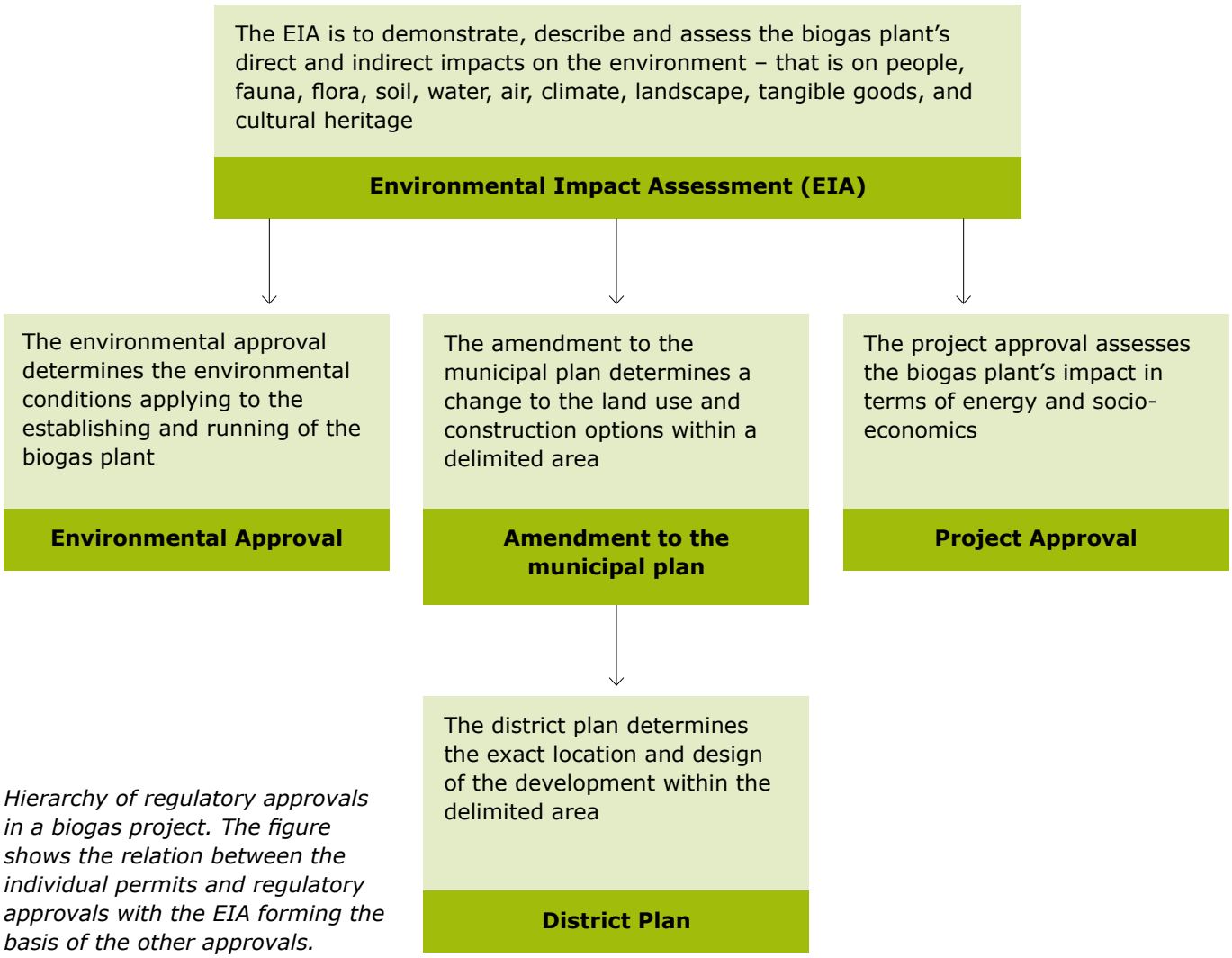
An essential part of the activities in phase 2 is related to regulatory approvals. By using the objective-oriented planning, two important issues became relevant in regards to Solrød Biogas, i.e.:

1) To systematically integrate core environmental and climate objectives into the preparation of regulations:

- Reducing the odour from digesting seaweed on the beach.
- Reducing the content of nutrients in Køge Bay and the washing out of nutrients from the agricultural industry.
- Reducing the overall greenhouse gas emission of Solrød Municipality.

2) To recognize, that the location of the plant is imperative vis-à-vis getting the required permits and regulatory approvals, why the following considerations became highly relevant:

- The plant must be located as close to the suppliers of biomass as possible. Transport of biomass is the largest single cost in the running of the plant and consequently, optimising the cost of transport is an important factor in the efforts of achieving a healthy and sound economy.
- The plant must be located in the vicinity of the energy client with a view to reducing the cost for transmission pipes.
- Various other planning considerations have to be met – among others:
  - Distance to neighbours and not closer than 500 metres from an urban zone.
  - The volume of traffic being generated around the plant in connection with transport of biomass.
  - Restrictions in relation to air traffic.



Hierarchy of regulatory approvals in a biogas project. The figure shows the relation between the individual permits and regulatory approvals with the EIA forming the basis of the other approvals.

These issues were considered in preparing the following permits and regulatory approvals for the biogas plant:

- EIA (Environmental Impact Assessment) in compliance with the Danish Act on Environmental Impact Assessment.
- Environmental approval in compliance with Section 5 of the Danish Environmental Protection Act (the Order of Environmental permitting).
- Amendment to the municipal plan in compliance with the Danish Planning Act.
- District plan on rural zone impact in compliance with the Danish Planning Act.
- Project approval in compliance with the Danish Heat Supply Act.

The EIA provides assessments of the impact of the biogas plant on the surrounding environment, and these assessments subsequently form the basis for determining the terms and requirements of the other approvals, cf. the figure below. In practise, however, the EIA, the environmental approval, and the amendment to the municipal plan are prepared in parallel.

The illustration below summarises the expected environmental impacts of the biogas plant, identified in the EIA.

Fact Sheet		
Annual CO_2 reduction	40,500 tons	55% of the municipality target value
Annual nitrogen reduction in Køge Bay	60 tons	72% of the reduction requirements for Køge Bay
Annual phosphorous reduction in Køge Bay	9 tons	100% of the reduction requirements for Køge Bay
Nitrogen wash-out from farmland	Reduced	Depending on crop
Impact on employment	Positive	6-8 full-time jobs
Impact on health	Positive	Reduction in noxious emission
Impact on animal life	Insignificant	No identifiable impact
Impact on nature and environment	Insignificant	No identifiable impact
Impact on water table interests	None	Risk of pollution insignificant
Obnoxious smell from plant	Insignificant	Potentially during maintenance/removal of sand
Obnoxious smell from spreading liquid manure	Reduced	Impact on the entire spreading area
Obnoxious smell on the beach	Reduced	Systematic beach cleaning
Noise nuisance	Insignificant	Especially around the plant
Traffic problems	Some	Increased transport via Naurbjerg
Visual effect	Negative	Shielded by additional planting

Environmental impacts

In addition to the approvals regarding the location and the production of the biogas plant, regulation also exists with regards to the spreading of digested biomass from the plant.

An assessment must therefore be made prior to the spreading of digested biomass as to the potential damaging environmental effect on the farmland vis-à-vis the current introduction of liquid manure or fertiliser. Responsibility for performing the assessment rests with the biogas plant, and this both applies to livestock farming and to agriculture. Put in short - if the strain on the environment from the digested biomass is less than from liquid manure and fertiliser, the agriculturalist needs to apply for an approval for spreading the digested biomass with the municipality in accordance with the requirements under the Danish Decree on Sludge. If the strain on the environment is higher, the biogas plant is to perform an EIA screening of the digested biomass at the farmland in question and, depending on the outcome, perform an EIA.

Manure spreading.

LESSONS LEARNED

Firstly: It is vital to have focus on the location of the plant and what is in the best interest of the biogas plant. A traditional approach would assess the plant's potential locations from the existing site requirements, but often these are restrictive when it comes to biogas plants and their environmental advantages. Instead, focus should be on the best location for the plant cf. the plant's environmental objectives. Then existing locational requirements can be met afterwards.

Secondly: Be aware that work at this level takes time. Permits and regulatory approvals are due at different intervals and have a built-in hierarchy. Yet they need to be drafted up more or less simultaneously with a view to averting unnecessary duplication and ensuring consistency between the permits.

Thirdly: Be abreast of future tasks and challenges in order to generate a flow in the regulatory approval process. This requires early planning of the entire process, and it is vital to form a general view of the entire process at an early stage, including the political decision-making process and the holding of public hearings. This also implies that the public and the most important stakeholders need to be brought into the project early in the process. Make use of technical pre-hearings, etc. by allowing stakeholders a say from the very beginning.

PROCUREMENT

As the concept of the biogas plant is beginning to find its shape and the work on regulatory approvals is coming to the last phase, the construction of a biogas plant is to be put out in a call for tender. In Solrød, it was decided that the construction of the plant was to be put out as a tender for turnkey contract, and that the bidder also had to bid on the first five years of operation of the plant. As the total construction costs were by far exceeding the EU procurement thresholds, the contract of construction and operation of the biogas plant was put out as an EU tender. Because the tender was about a supply company, the contract was put out as a tender through the *'Directive 2004/17/ EC of the European Parliament and of the Council of March 31, 2004 coordinating the procurement procedures of entities operating in the water, energy, transport, and postal services sectors'.* This directive allows among other things the possibility to conduct negotiations with the bidder after submission of bids.

As mentioned, it was decided that the construction of the plant was to be put out as a tender for turnkey contract. This was partly because of the acquired experiences from other Danish biogas plants, and partly because Solrød Municipality as a public authority neither has the experience nor the resources regarding construction and operation of a biogas plant.

To help prepare the call for tender for the turnkey contract, a call for tender for technical advisor was first carried out. It was found important to prioritize advisors with in-depth knowledge of the biogas industry. This tender resulted in eight bids, whereafter the company GasCon was chosen. Besides the technical advisor, legal and financial advisors were also bought in to assist in the preparation of the tender for the turnkey contract through revisions of business plans, formulation of contracts, etc.

In order to introduce the technical advisor to the comprehensive work up to this point of the project, an initial workshop was held with the participation of GasCon, Solrød Municipality, and VEKS. At this workshop, the location and basic design of the facility was also determined. Hereafter, a procurement plan was developed including a revised time schedule. It was decided to carry through the tender in two steps. The first step was a prequalification round, where three bidders were chosen to the next round. The second step was the final choice of bid among the bidders.

First round: A request for tender (pre-qualification) was publicised. The bidding documents included instructions for submission and information on criteria for bid evaluation, general and specific conditions of contract with performance obligations and payment terms, scope of supply and technical specifications based on the principle technical design, time schedules, requirements for documentation of the bidder, and requirements on quality assurance.

Niels Hörup, chairman of Solrød Biogas A/S, signs contracts with CP Kelco, VEKS, Chr. Hansen, Bigadan, and local farmers.

Second round: Final bid on contract for construction and operation of the plant: The technical advisor completed a detailed outline of the submitted bids. On this basis further instructions to bidders were requested and meetings were set up with each bidder.

As a result of these two rounds the company Bigadan A/S was selected to construct the biogas plant and to operate the plant in the first five years. The selection of Bigadan A/S was based on the predefined criteria.

LESSONS LEARNED

The tendering procedure to select a technical advisor (and the buy-in of legal and financial advisors) provides the assistance of qualified consultancy, which is necessary in order to do a successful call for tender for turnkey contract. With the new procurement rules allowing negotiations prior to selection of contractor this could be further exploited. It was found valuable to include experienced advisors, with in-depth knowledge of the biogas industry, and it is advisable to consider whether the organization behind the biogas project has the necessary resources to oversee the construction and operation of a biogas plant without a turnkey contractor.

Niels Hörup and Karsten Buchhave, CEO at Bigadan A/S. Photo: Peter Jarvad

CONTRACT DESIGN AND ECONOMICAL ASSESSMENTS

By the end of phase 2 contracts are to be signed with suppliers, outlets, and the contractor. The design of the contracts is, however, an ongoing process with numerous meetings with the stakeholders and continuous considerations regarding the final input-output balance of the plant as well as the final economic budget.

Relating the contracts to the financial budget

The budget is in many ways a recapitulation of the entire project, and a main task is therefore to continuously gather and evaluate all components of the project from a financial point of view. The most important component in respect of the budget is obtaining bilateral, economically profitable agreements with suppliers and customers. The placing of contracts and the contract content imply a thorough preliminary work ensuring a consistent supply of raw materials and the derived highest possible gas yield. Simultaneously, an important task involves identifying the legislation on subsidies and transfer prices within the supply area.

Generally, the budget and therefore also the contracts should reflect a business plan that ensures financial, social, and environmental sustainability of the municipal investments. The financial sustainability – the profitability ratio, relevant in this case, implied that the plant needed to have a short payback period of about 10 years seen in proportion to the actual life span of the plant.

Important features when designing contracts

The following basic conditions, developed through negotiations with suppliers and customers and by on-going discussions internally within the project group, are found to be of importance when designing contracts:

1 The profitability of the plant is a direct consequence of the gas yield. The more gas sold to the gas customer, the higher revenue. Therefore, all larger changes in the biogas production must be considered in proportion to the gas output and the budget´s profitability. The most important items in the contract with the gas customer were: 1) That Solrød Biogas A/S produces the gas and the customer establishes, owns, and runs both the gas engine at their own local installations and the gas pipe from Solrød Biogas A/S to the customers. The gas engine runs the generator producing electricity to the public network, while the waste heat is used for district heating. 2) That the price per produced MWh of heat, including financial charges, produced at the customers´ biogas engine installations must not exceed the heat price ceiling for waste incineration plants including a deduction of 10%. The market price for heat is deduced from the expected average purchase prices for energy, according to the customers, in the years to come. The average purchase price is used as the price of reference when paying for heat produced from biogas.

2 The total supply of raw materials has to be determined in order to have a basis for the calculation of the gas yield and, by that, the revenue and also the investments in the plant. As the expected composition of the raw materials is not used in any other installation in Denmark, it was of great importance to the business model that the gas yield could be estimated, and that it was possible to determine the lower values with a high degree of certainty. A number of decomposition tests are to be carried out for this purpose. Before the plant is profitable, the revenue must balance the investment costs and give the necessary liquidity surplus within the stated investment horizon.

3 To ensure that the contracts bring in a reasonable revenue from the gas yield, it is essential also to evaluate the present as well as the future changes in transfer prices for the biogas. In March, 2012 the Danish government, together with important parties of the opposition, agreed on "The Danish energy policy 2012-2020". This energy policy, and other bills on increased subsidies for electricity produced from biogas production, form the primary basis for the conditions concerning the transfer price.

4 The determined total supply of raw materials also implies that the contracts have to be formulated in a way that includes bilateral obligations on each quantity of raw material. In other words, it is essential to secure that the biogas plant is not short on a quantity of raw materials at the point of full production.

5 In case of possible changes in the supply and composition of raw materials, the contracts should also attach importance to compensation models, which are included as part of the financial basis. An example of such compensation is given below.

6 When determining the supply of raw materials it is subsequently possible to calculate the exact sales requirement of the digested biomass and enter contracts on the basis of this.

7 The determined supply of raw materials also plays a significant role in the calculation of the costs in connection with the establishment of the biogas plant in respect to the installation capacity, storage of digested biomass, and transport to and from the plant.

An example of basic conditions in agreements with suppliers of liquid manure

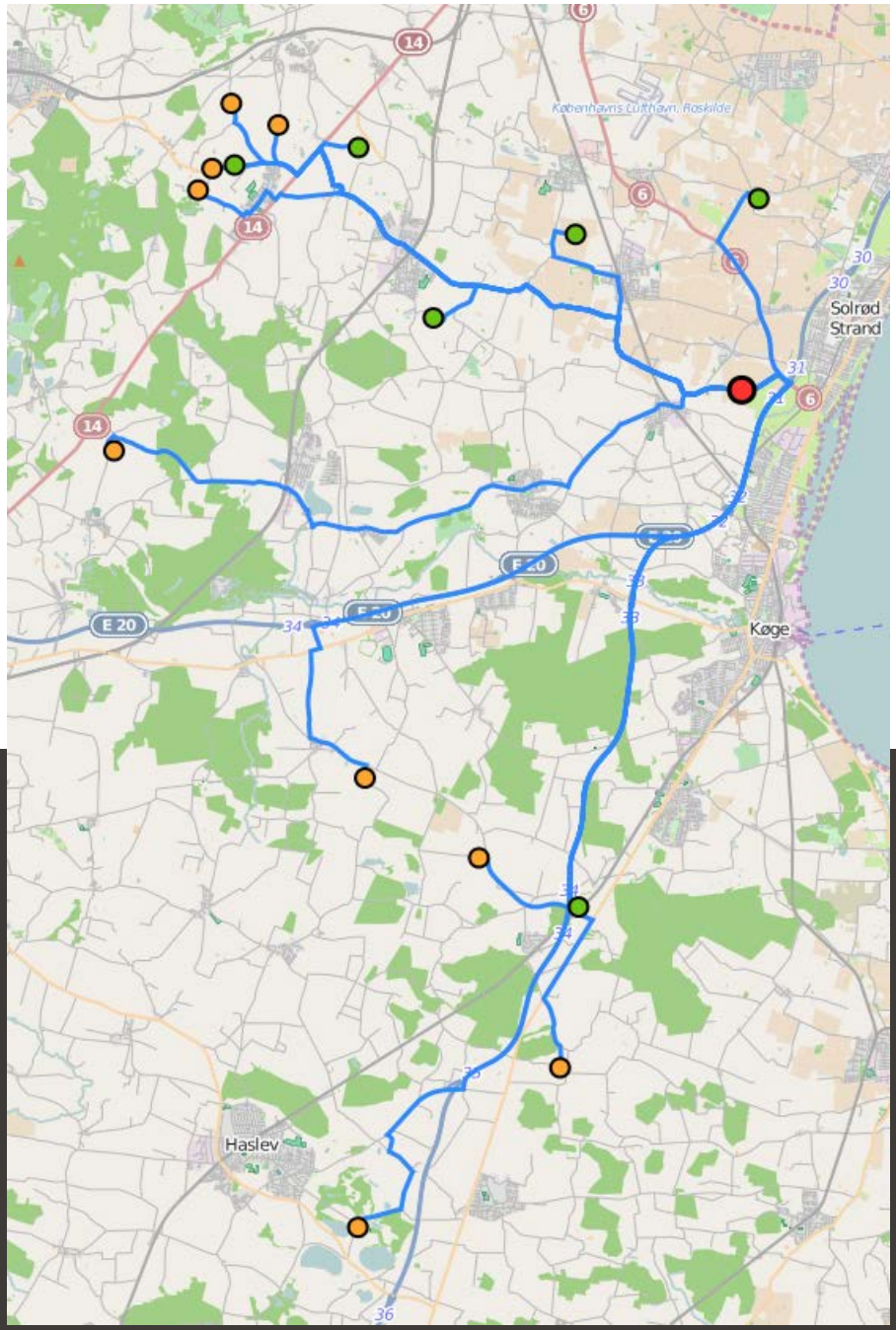
The biogas plant is to process 200,000 tons of biomass annually, of which 53,000 tons of liquid manure derive from local pig farms. Following digestion of the biomass at the plant, the by-product will constitute approx. 190,000 tons to be spread as manure and a soil improvement product on farmland. The suppliers of liquid manure are to take digested biomass equivalent to the quantity of liquid manure supplied – that is 53,000 tons. The suppliers of liquid manure all have the required storage facilities. The remaining 137,000 tons of digested biomass are to be delivered to farmers on Zealand.

Based on conversations with the potential suppliers of liquid manure and recipients of digested biomass as well as the farmers' associations, the project group listed the following conditions in the agreements made with the suppliers of liquid manure:

Solrød Biogas A/S is responsible for collecting the liquid manure from the receiving tank and transporting it to the biogas plant for digestion.

Solrød Biogas A/S returns the digested biomass to the supplier of liquid manure and delivers it into storage tanks at the farm.

The supplier of liquid manure is required to have a receiving tank with the capacity to hold a full lorry load of about 38 m^3, and to make sure that the access road leading up to the tank is in a condition to manage larger lorries. The supplier is offered a compensation of DKK 4 per ton per year for the first 5,000 tons, DKK 3 per ton between 5,000 and 10,000 tons, and DKK 2 per ton for quantities above 10,000 tons a year.



Distance between Solrød Biogas and suppliers/outlets.

The supplier of liquid manure receives a bonus for supplying liquid manure with a high percentage of solid matter. As a benchmark, the suppliers of liquid manure are to supply liquid manure from e.g. porkers holding a solid matter content of 5 – 6%. If the content of the liquid manure supplied is higher, the supplier receives a bonus equivalent to DKK 5 per ton/percent of solid matter. Reversely, in the event the content of the liquid manure supplied is lower, the supplier is to pay.

The supplier of liquid manure is compensated if the manure contains more kilogrammes of nitrogen per ton (N/ton) than he receives in the form of digested biomass. Based on a content of nitrogen of 4.24 kilogrammes per ton, the supplier will not be subject to compensation in the 4.1 – 4.5 kilogramme interval. For every increase of 0.1 kilogrammes N/ton in the liquid manure, the supplier will be compensated DKK 1 per ton. Similarly, if the content of nitrogen in the liquid manure is below 4.1 kilogrammes N/ton, the supplier is to pay DKK 1 per ton of liquid manure for each 0.1 kilogrammes N/ton below this benchmark. The compensation is calculated on the basis of also covering fluctuations in the content of phosphorous.

The map on page 32 illustrates the distance between the biogas plant and the suppliers of liquid manure and potential recipients of digested biomass respectively, as of October 1, 2014.

Constructing the base of the administration building, November 2014.

LESSONS LEARNED

It is essential to be aware of the connection between the gas yield of the plant, the raw material balance, and the financial potential. Cross-level reflection in respect to contract drafts and agreements concerning supply and purchase of biomass and biogas is necessary in order to secure a reasonable business and financing plan.

In order to facilitate negotiations and drafting of the contract design it is conducive to;

- Initiate an information campaign targeting suppliers of liquid manure and agriculturalists with a view to introducing the digested biomass on the market.
- Draw up a declaration of content related to the digested biomass listing the content of nutrients, solid matter, and environmental-injurious substances, etc.
- Engage the local agricultural consultants in the campaign with a view to playing an active part in "selling" the concept to farmers.
- Involve local farmers and agricultural consultants in drawing up the agreements. This will ensure that the digested biomass is adapted to the agricultural requirements applying to nutrients, spreading, storage, etc.

CONCLUSIONS AND LOOKING AHEAD

It is not easy to make the changeover from fossil energy supply to renewable energy. It is therefore essential to generate an understanding of the numerous considerations inherent in the development of renewable energy and the establishment of a biogas plant.

This publication accounts for the planning of the work of the Solrød Biogas plant but it also emphasises lessons learned, the development work, and aspects which we believe could be useful for others in relation to establishing a biogas plant or other types of renewable energy plants.

We are convinced that our experiences from establishing the Solrød Biogas plant are useful in other parts of Denmark and in the EU. The objective of promoting renewable energy is the same everywhere, but local conditions may differ significantly.

The conditions for local cooperation between agriculture, industry, and local authorities vary from region to region, but cooperation is the key to success.

Raw materials will be different, but in many parts of the EU the issues are the same as in Solrød, e.g. washed up seaweed as a result of the addition of nutrients to the ocean is a major environment and health issue. The seaweed can be used in biogas plants, but such use requires further in-depth studies and testing.

Looking ahead, the Solrød Biogas project culminates in the current construction phase (phase 3), and we expect to see green energy flowing from the plant in the summer of 2015. With the stable operation of the plant from autumn, 2015 Solrød Municipality can put all efforts into other ongoing transition initiatives such as transforming fossil fuelled villages into self-producing renewable energy villages, promoting district heating and alternative heating systems, energy efficiency activities, reducing use of fossil fuel in transportation, etc.

> With the biogas plant we take a huge step to reduce CO_2 emissions. My hope is that other municipalities and private actors in Denmark and in other countries will be inspired and copy our project in order to seriously address the issue of climate change and contribute to the transition towards renewable energy.
>
> *Niels Hörup*

Collaborative partners at the sod turning ceremony – 'cooperation is the key to success'. Photo: Peter Jarvad

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SOLRØD KOMMUNE

ROSKILDE UNIVERSITY

VEKS

CPKelco
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CHR. HANSEN

BIGADAN

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