ROKEL PIG FARM BIOGAS DEMONSTRATION PLANT

Final Report

by
Niels Ansø, Preben Maegaard & Jacob Bugge

Folkecenter for Renewable Energy

March 2000

Supported by the Danish Environmental Protection Agency
Project No. M 127-0603

ISBN 87-7778-117-1
FC-print

Nordvestjysk Folkecenter for Vedvarende Energi

Folkecenter
for Renewable
Energy

P.O.Box 208
Kammersgaardsvej16
Sdr. Ydby
7760 Hurup Thy
Denmark

T: +45 97956600
F: +45 97956565

energy@folkecenter.dk
www.folkecenter.dk

CONTENTS

Location

The Vycia farm where the biogas plant is installed is situated in Rokai 15 kilometres south of the centre of Kaunas. This central situation of the Vycia farm is excellent for demonstration of the biogas technology.

Kaunas is the second largest city in Lithuania counting about 400.000 inhabitants. It is situated in the southern central part of Lithuania at the junction between the 2 rivers Neris and Nemunas. Kaunas has several larger educational institutions, e.g. Kaunas University of Technology, Lithuanian University of Agriculture and Lithuanian Energy Institute.

List of abbreviations

CHP	Combined Heat and Power unit
DANCEE	Danish Cooperation for Environment in Eastern Europe
DEPA	Danish Environmental Protection Agency
DESF	Danish Environmental Support Fund for Eastern Europe
KUT	Kaunas University of Technology
LEI	Lithuanian Energy Institute
LUA	Lithuanian University of Agriculture

Executive Summary

The project was performed during four years between early 1996 and early 2000.

The main purpose was to demonstrate the prospects of modern Danish biogas technology and to transfer the technology to Lithuanian enterprises for further market development.

The primary result of the project was the projecting, installation, implementation, and initial operation, of a biogas plant on the large pig farm Vycia in Rokai near Kaunas, Lithuania, with the aim to supply the farm with electricity and heat.

The biogas plant presents itself as an outstanding building complex and a modern renewable energy plant of a high professional standard.

Hitherto, the Vycia farm has been supplied with electricity from the Ignalina nuclear power plant. All heat consumption, including heating of the stables, has been covered by electricity. The total annual electricity consumption at the farm has been 3700 MWh; 2300 MWh or 62% has been used for simple heating and only 38% for electricity.

The conventional alternative to the Ignalina plant in case of shutdown is a continuation of the hitherto electricity consumption at the farm based upon a traditional coal-fired power plant. The biogas plant represents an alternative to the existing conventional energy supply in Lithuania and demonstrates in practice how local resources can replace centralised supply of energy.

With a professional operation of the biogas plant, the total amount of conventionally produced electricity used for both power and heat can be replaced by renewable energy with annual savings of more than 1 million DKK. With a total project budget of 4,44 million DKK, the simple payback time is between 4 and 4,5 years. The total Danish public funding was 3,8 million DKK.

In addition, the processing of the manure reduces the pollution of air and groundwater at the farm. Consequently, a lasting direct environmental impact will be achieved, mainly as a reduction in greenhouse gases. As compared to a coal-based electricity supply, the reduction amounts to 5746 tons of CO_2/year. The corresponding key figure for the Danish project funding is 1,50 kg CO_2/year/DKK. As a comparison, the key figures for the various national Danish energy support programmes ranged from 0,04 to 1,10 kg CO_2/year/DKK in 1999.

The project was concluded successfully, and it is hoped that this demonstration project will be the starting point of a large-scale biogas development in Lithuania. Experiences with other biogas installations show that the full gas production is generally achieved after 1 – 2 years of operation as the learning process is completed at the operational level.

1 Introduction

The project has been supported by the Danish Environmental Protection Agency (DEPA) according to the Act on Subsidies for Environmental Activities in Eastern European Countries through the support fund DESF, from 1999 DANCEE.

The initial project preparations formed part of the Folkecenter for Renewable Energy project 'Vedvarende energi infrastruktur i Østeuropa' (Renewable energy infrastructure in Eastern Europe) which was carried out between 1992 and 1995 with support from the Danish Environmental Protection Agency under the Journal no. M 807-0149. This earlier project was based upon Folkecenter activities and contacts in Eastern Europe since 1990. The Energy Office Kaunas was established in 1993 and was involved throughout the present project.

The underlying concept was a combination of demonstration of farm biogas and technology transfer with a direct involvement of the local industry through co-production. To secure the sustainability of the technology transfer and biogas operation, the Lithuanian Energy Institute was involved from the very beginning to assist in the theoretical part. The Lithuanian University of Agriculture participated in the technology transfer as well.

2 Project context

In Lithuania, many large cooperative farms have turned into private enterprises, but generally there have been no radical changes in the production methods. One of the farm types is pig farms without plant production. On such a farm, manure is considered a waste product, and no arrangements have been made for its use as a fertilizer. The manure is simply removed from the stables and stored in the open. Consequently, all the organic matter will eventually pollute the air and groundwater.

Biogas is the technology which turns this waste into renewable energy and more stable organic matter and even enhances the value of the manure as a fertilizer by mineralization of organic bound nitrogen.

Biogas is produced through an anaerobic fermentation process by a complex bacteria culture. In order to optimize the production, the process must be stable with only gradual changes in the supply of organic material and temperature to ensure an optimal adaptation of the bacteria culture. In fact, the bacteria should be regarded as domestic animals and treated with the same care as cows, pigs, and fish in fish farms.

Farm biogas production forms an integrated part of the agricultural activities, and a significant part of the energy is used at the farm.

The concept which has become the standard Danish type is an advanced biogas plant with insulated steel process tank supplied with agitators. The biogas process is kept constant through frequent interval feeding for optimization of the fermentation process. The use of fresh manure and up to 10% of well-defined wastes enable a high production and effective utilization of the biogas plant. The gas operates a CHP unit and a separate gas boiler. The whole system is thoroughly monitored and is supervised as part of the normal routines on the farm. This biogas concept was developed by Folkecenter since 1986.

As it appears, the gas production depends entirely upon the care and skill of the operator. Danish experience shows that the production on identical biogas plants with identical organic basis may vary with a factor 3 or more.

With this, biogas differs fundamentally from other renewable energies like wind and solar power. The biogas plant itself is not producing energy like a windmill or a solar panel, and it is impossible to guarantee a specific production. Instead, a biogas plant is a production facility similar to a stable system: the functionality can be guaranteed, but the production depends upon the operation, including the quantity and quality of the fodder.

This means that a successful biogas project includes the establishment of a well-functional technology, an adequate transfer of knowhow, and a demonstration of the production potential. The responsibility for the actual production and the long term success of the biogas plant rests solely with beneficiary.

The following 3 criteria's are considered to have the same importance for a successful operation of a biogas plant:

1) Technology
2) Raw material
3) Operation and care

3 Project outputs

3.1 Activities

Time schedule for main activities																	
1994-1995	1996				1997				1998				1999				2000
Application	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
Planning and preparations																	
Implementation																	
Starting up																	
Follow up																	
Training activities																	
Reporting																	

The table shows the time schedule for the main activities for the project.

3.1.1 Preparations and contracts

The original project application was presented in April 1994 in parallel with another proposal for biogas demonstration in Lithuania and following two other biogas demonstration proposals in Eastern Europe. The application was elaborated in co-operation with the Lithuanian Energy Institute (LEI) and VYCIA, and it was recommended by the Lithuanian Ministries of Energy and Agriculture as well as the Kaunas District.

During the rest of 1994 and most of 1995, the further preparations included choice of priority between the four biogas proposals in favour of the present project, liability statements covering the Lithuanian cofunding, and approval from the newly established Environmental Protection Ministry of Lithuania.

The application was approved by the DEPA in November 1995.

The actual project work started in 1996 with visits to the VYCIA farm for planning and inspection followed by test digestion of manure samples. The inspection and the test digestion confirmed the basic quality of the manure, but revealed that a radical modification of the manure handling system was necessary.

Picture 3-1 At the introduction visit in January 1996, Folkecenter Director Mr. Preben Maegaard explains engineers from the Vycia farm and Kaunas Energy Office, and researchers from LEI, about the biogas technology and the potential for energy production.

Picture 3-2 The county mayor of Kaunas district was visited and informed about the state of the project and the coming implementation of the biogas installation at the Vycia farm. He promised the full support of the local authorities.

Picture 3-3 A working day is completed. The Vycia farm hosted an official dinner where intensions and agreements for the future cooperation can be declared.

Representatives from Vycia farm, LEI, and ICC, visited Denmark in the spring 1996 to study the farm biogas installations and to prepare projecting and implementation.

During 1996, the projecting of the biogas plant was performed in parallel with discussions and planning concerning the changes in the manure handling system. Based upon a call for tenders, the Lithuanian firm ICC was chosen as Lithuanian supplier of the biogas digesters. The volume of the digesters itself was prohibitive for import of this component. The contract with ICC was signed at the turn of the year 1996/1997, and the contract with VYCIA was signed in February 1997.

Picture 3-4 In August 1996, a Danish agriculture consultant was engaged to analyse the stable and manure handling system at the Vycia farm in order to find solutions for the significant water spill and the consequent dilution of the manure. On the picture, the Danish expert together with the technical engineer and a researcher from LEI inspects the stables. In the top middle of the picture is seen how the drinking outlets are situated over the manure channels so spilled water goes directly to the manure. Instead the drinking outlets should be placed over the trough so the pigs have easier access to drinking when eating, and so spilled water would be mixed with the pig food. In the top left side of the picture an eating pig is shown with the drinking outlet behind it.

3.1.2 Training

Already before the application for this project was made and approved, Folkecenter started to invite people from the Lithuanian side to Folkecenter to study biogas technology in reality. Later on during the implementation of the project, this activity was continued and also extended to include other branches such as programming software for control system for biogas plant.

2 study trips to Denmark were arranged for the Lithuanian partners. In the spring 1996, key persons from Vycia Farm, ICC, and LEI, came to see biogas plants similar to the one planned in Lithuania. This happened at the same time as an Assoc. prof. from Lithuanian University of Agriculture (LUA) participated in a training course at Folkecenter. In March 1999, another study trip was arranged. This trip was based on the first practical experiences, which the Lithuanian partners had made by operating their own biogas plant. The programme for this trip is enclosed in Annex J, Programme for biogas study and working trip to Denmark.

The following persons have participated in training courses at the Folkecenter during the project:

Mr. Juozas Savickas, Senior research associate, Lithuanian Energy Institute, LEI.
Mr. Savickas was the first person with connection to the present project who participated in a training programme at the Folkecenter. The training course, sponsored by WAITRO and Folkecenter, took place at the Folkecenter during 1 week in August 1993. 7 participants from different countries got knowledge in anaerobic fermentation of organic waste, became acquainted with the microbiological process in the digesters, and learned to estimate the mainly parameters of biogas, organic waste (substrates) and environmental factors. Several biogas plants in Denmark were visited.

Mr. Savickas also participated in the study trip in March 1999.

Associate Professor, Dr. Kestutis Navickas, Lithuanian University of Agriculture, Department of Agroenergetics.
Mr. Navickas participated in a training course at the Folkecenter during the 3 first month of 1996. The main task of this training course was study of biogas technology, laboratory tests of raw material, study of Danish experience, Vycia Demonstration Biogas Plant project implementation, and technology transfer. During the course, 6 farm biogas plants and several centralized biogas plants were visited, for example by participating in a farm biogas monitoring programme. Mr. Navickas participated in the preparation of documentation of the 300 m^3 digesters for Lithuania as well as in the laboratory testing of manure samples from Vycia.

At present there are four students (1 Bachelor, 1 Diploma Engineer, 2 Masters) in the Lithuanian University of Agriculture, working with projects related with Vycia Biogas Plant.

Mr. Gintaras Dervinis, Kaunas University of Technology.
Mr. Dervinis was included in the project during a 2-months stay at Folkecenter from April to June 1998. The purpose was to study biogas related computer control technology and to be part of the transfer of this technology to Lithuania. For future changes to the control system at the actual biogas plant at the Vycia farm and to new biogas plants in Lithuania, local expertise should be able to do the work.

Mr. Algis Lukosevicius, Electrician and Operator of the biogas plant at the Vycia Farm.
Mr. Lukosevicius participated as an electrician in the implementation of the biogas plant. After starting up of the biogas plant and real experiences could be obtained, Mr. Lukosevicius participated in a study trip to Denmark in March 1999. Participating in the daily work on one of the smaller centralised biogas plants in Denmark finished the trip.

Training in Lithuania.
During most of the visits in Lithuania during the implementation period, information and training activities have been carried out by unofficial co-operation and meetings concerning specific problems and the project concept in general. These activities continued after completion of the construction period into the follow up period. Now questions from Lithuanian side got a new dimension since they were based on practical experiences with their own biogas plant.

In March 1999, Mr. Karl Erik Jensen, manager of the local community biogas plant, Vester Hjermitslev Biogas, Denmark, visited Lithuania to give practical advises to the people operating the biogas plant at the Vycia farm. Mr. Jensen has 15 years of experience with a biogas plant, which is known in Denmark for presenting very high gas yields. During the visit, Mr. Jensen and the Lithuanian people involved in the daily operation of the biogas plant held very constructive meetings and discussions concerning practical operation of the biogas plant at Vycia.

Picture 3-5 Surprising for the Lithuanians, Mr. Jensen demonstrates the necessity to literally grip the problems from their most practical side. On the picture Mr. Jensen analyses a manure sample taken from the sand outlet in the bottom of one of the digesters. There has been a periodical problem that the manure outlets of the digesters blocked. The conclusion was that the high contents of sawdust sedimented in the digester and blocked the outlet. The solution was more frequently emptying of the sand outlet and more operation with the agitators when fresh manure was added, and digested manure should escape through the manure outlets. This should avoid sawdust blocking the outlet, and help to transport sediments out of the digester.

3.1.3 Technology transfer

The technology transfer part of the project has been considered very important. The purpose has been to transfer as much knowledge as possible in order to give the involved Lithuanian partners the knowledge and skills to continue further dissemination of biogas technology in Lithuania by the end of this demonstration project.

Biogas process
As mentioned in chapter 3.1.2, two scientists from two institutes in Kaunas region have participated in biogas process related training courses at Folkecenter. The purpose of these training courses has been to educate Lithuanian people who can participate in optimisation of the present biogas plant by analysing results and finding appropriate organic wastes as from food industry. Another purpose not less important is to contribute to the further dissemination of biogas technology in Lithuania.

After starting up of the present biogas plant, practical experiences have been obtained and questions based on own experiences occurred. The daily operator of the biogas plant has participated in a more practical oriented course where he participated during one week in the daily work of a smaller centralised biogas plant in Denmark.

Biogas digesters
The biogas digesters were delivered by the Lithuanian company ICC. The heavy steelwork seemed natural for the company. The biogas specific parts of the digesters such as agitators, heat exchangers and valves system were new to them. The technology was transferred through drawings, part lists, and instructions, from Folkecenter.

Insulation
The insulation work of the 3 digesters was included in the contract with ICC who had great experience in the construction of larger insulated tanks. Nevertheless there came a discrepancy on the

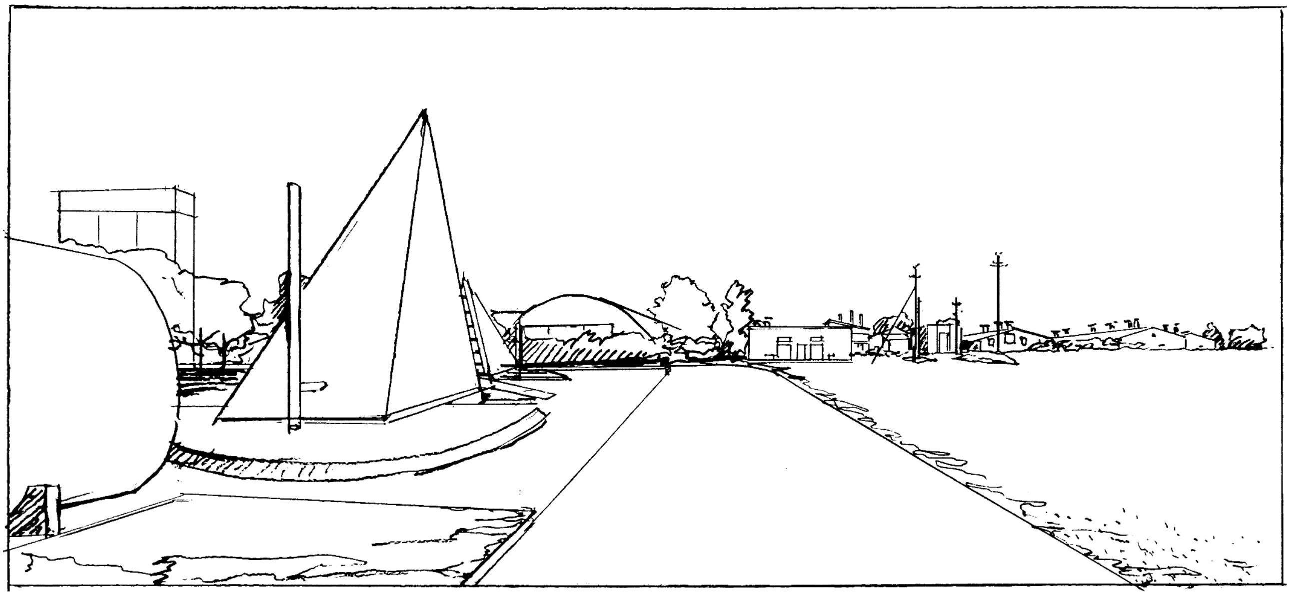
question of the quality of the insulation work presented by ICC, first of all the visual appearance of the digesters. It was concluded that the technology ICC used for very large vertical tanks was not suitable for the horizontal biogas digesters. It was also clear that the understanding of "professional appearance" differed between Lithuania and Denmark. Long discussions on quality of materials and change of working methods ended up in a agreement with ICC which included supervision by a supervisor from a Danish insulation company. The Danish side paid the 1st week for the supervisor, and the following time until completion of 1 digester was paid by ICC. Materials for covering plates were purchased in Denmark for ICC. After 2 weeks, the first digester was completed, and the final result differed very positively from the first one presented.

Biogas plant and piping
The Vycia farm was contractor on the main parts of the biogas installation excluding the digesters and the gasholder. Part of the work was done by other subcontractors, for example pile foundation to the biogas digesters. This position of the Vycia farm has given perfect conditions for receiving all necessary information related to biogas technology, for example gas system, heating system, and manure system.

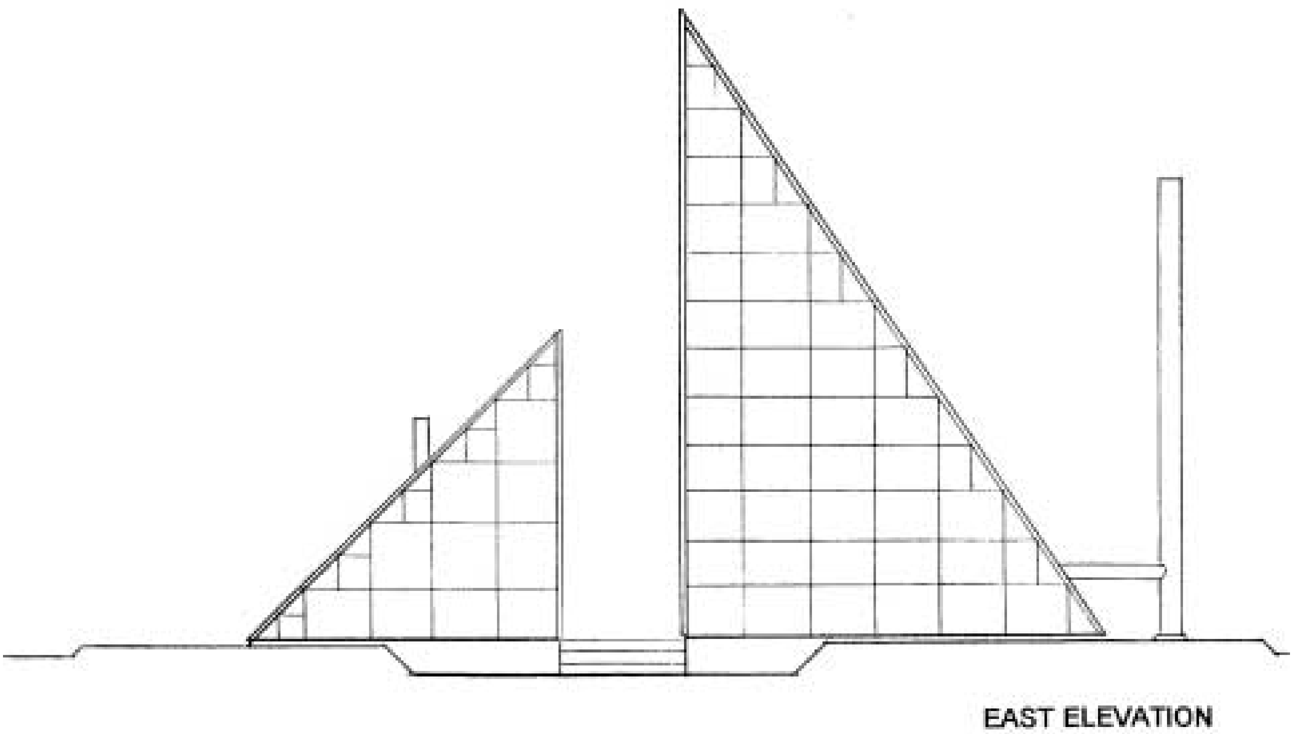
Biogas computer control system
An engineer M.Sc. from Kaunas Technologic University programmed the software for the computer control system. In this way, local expertise was developed and could be available for future changes on this specific biogas plant and on future new plants in Lithuania.

3.1.4 Implementation

The final preparations before the implementation ended in December 1996 with a trip to Lithuania. One of the purposes of this travel was to clarify which equipment was available for purchasing locally, and which equipment had to be purchased in Denmark. Also the design of the technical building and situation of the biogas plant in general was presented to the Vycia farm.



Picture 3-6 The Danish architect Kenneth Olsen MAA suggested the technical buildings situated centrally at the Vycia farm as a landmark and rotation point between the waste water facilities and the main entrance to the farm. Included in the suggestion was also the location of the digesters and other biogas-related objects in relation to the existing building complex. See also Picture 3-20.



Picture 3-7 A remarkable design of the technical building was suggested. Later on, the building has been mentioned as "the cathedral". The design was chosen to give status and to catch attention for this first biogas demonstration plant in Lithuania. The smaller building to the left contains the relatively noisy CHP´s. The ground floor of the other building contains boilers and other technical equipment, and the first floor contains laboratory, control system and functions as demonstration area.

The construction of the biogas plant started January 1997. Vycia farm was responsible for the foundations that should support the digesters.

Picture 3-8 The pile foundations were made in January 1997, and the concrete casting part of the foundation was completed as soon as the weather allowed. One digester foot has arrived at the site.

Meanwhile ICC started purchasing and prefabrication of the steel for the digesters. ICC continued their work independently of the discussion about the financial guarantee, which was a part of the contract. That meant that ICC worked at their own risk and without any payment until the guarantee was established by the end of July 1997.

Picture 3-9 The picture was taken in May 1997. The first two of the 4,2 meter diameter and 8 meter long sections of the 1st digester have been placed on the foundations. The last one is still on the ground were it is welded together from four rings, prefabricated at the ICC factory in Mazeikiai, and welded together at the site.

An inspection visit was arranged from 15th of May, 5 days later than the scheduled delivery of the first digester. As it shows from the Picture 3-9, this delivery was delayed, according to ICC owing to problems with manufacturing parts of the agitator system and authority approval of project. ICC promised to catch up the delay by higher effectiveness on manufacturing of the 2nd and 3rd digester.

In parallel, the Vycia farm had almost finished the construction of the concrete tank for the gas storage system, the gasholder. Plans for the construction of the technical buildings were presented by a subcontractor and approved to be in harmony with the suggested design from the Danish architect, Mr. Kenneth Olsen.

Picture 3-10 The construction site at the inspection in July 1997. Two digesters are mainly constructed, one of them has the agitator system installed. On the right the four digester feet are seen on the foundations, waiting for the main tank for the 3rd digester. In the foreground of the picture is the foundation for the two technical buildings, motor building and boiler building respectively. In the background are the waste treatment facilities.

In the beginning of September 1997 all the digester bodies were constructed, and the agitators and manure valves were installed. The weldings had been tested and approved. An inspection of the digesters was carried out before the insulation work started.

A smaller problem occurred when it became clear that steel profiles of Russian origin had less strength than the ones specified, even though they matched the outer dimensions. In agreement with Folkecenter, ICC solved the problem by installing extra profiles as reinforcement.

Picture 3-11 September 1998

Picture 3-12 There were many details to check during the inspections. On the picture, Mindaugas Stalnionis, Kaunas Energy Office, assists in the inspection of the agitator system in one of the digesters.

After the inspection in September 1997, only simple faults were noticed for correction, so the heavy steel construction work of the 3 digesters was accepted with respect to start the insulation work. A new inspection was carried out in October 1997, but only few faults had been corrected since ICC had concentrated on completing the digesters. Finally in December all faults had been corrected.

In September, the first digester was filled with water to test the tightness. At this occasion it was noticed that the foundation were settling more than acceptable from the 350 tons weight of each filled digester. At the visit to Lithuania in October, a meeting was held with the company responsible for the foundation work. The company had already taken initiative to reinforce the pile foundation. Complete documentation of the foundation including the original geotechnical investigations of the site was brought to Denmark. Consulting a Danish expert in foundation, the material was examined and the reinforcement solution was approved. It was concluded that the settling of the foundations was caused by special conditions in the soil.

At the same visit in October 1997, ICC presented the first insulation work of the digesters. They had started insulation on 2 digesters, but neither the appearance nor the technical quality was acceptable. Since the cover plate for the insulation is the dominating visible part of the digesters, no compromises could be accepted. The appearance should as reference match the quality as it was presented to ICC at biogas installations in Denmark. One explanation of the problem was that ICC had great experience in insulation work on larger vertical tanks, but not exactly in such horizontal tanks. Also the general understanding of professional appearance differed between Lithuania and Denmark.

The following months led into discussions between Folkecenter and ICC in their efforts to find a suitable cover plate material and to agree and document a change to technology matching Danish standards of insulation work. Finally in March 1998, ICC accepted that Folkecenter selected and purchased new cover plate material in Denmark at the expense of ICC. This material was only slightly more expensive than material of Russian or Polish origin, and it could be delivered in Lithuania within few days with full approval material certificates. Also ICC agreed to receive supervision from a Danish insulation company. The Danish side paid the first week, which under Danish conditions was sufficient to finish one tank. ICC had to pay for the supervisor for the time exceeding 1 week. After an additional week the insulation of the 1st digester was completed, and the improvement of the technical quality and the appearance was obvious. Later, ICC completed the remaining 2 tanks with the same fine result. The technology transfer to ICC was a success.

Picture 3-13 The supervisor from the Danish insulation company Scanca takes the last measures before departure to the ICC factory in Mazeikiai, where the prefabrication of the cover plate should take place. At the same time an employee from ICC dismounts the old insulation supports from the digester.

Picture 3-14 In September 1998 it was clear that the efforts transferring technology from the Danish insulation company to ICC was successful. Both the technical quality and the appearance were obviously improved and matched professional western standard.

In parallel with ICC´s work on constructing the digesters and the gasholder, Vycia Farm worked on construction of the technical buildings, piping for heating, manure and gas systems, and concrete tanks for the manure and gas system. From time to time the activity level on the building site was very high, and naturally different activities were depending on each other or directly obstructed each other. Usually, construction activities under the Vycia Farms reasonability followed the ICC activities, so delays would effect the later activities.

The main construction work of the technical buildings was finished by the end of October 1997. At the same time, the piping work started. In December 1997 the first cargo with technical equipment was sent by truck from Denmark. It contained the boilers, pumps, and other special equipment, for the heating system, which were either cheaper or only available in Denmark.

Transportation to Lithuania of equipment purchased in Denmark was performed by a Danish transport company, which had 2 weekly departures to Lithuania, mainly with cargo to the Danish textile industry established in Lithuania. For the project it was an advantage both for the transportation costs and for the safety of the goods underway, that this infrastructure already existed. Problems only occurred when the cargo should be declared by authorities in Lithuania. Normally cargo is declared when the truck arrives to the destination country or to a customhouse inside the destination country, after which the truck can deliver the cargo to the final destination. But since it was required from the Danish Environmental Protection Agency that the support to this project could not be subject to any kind of tax and custom fee, the declaration of cargo always met bureaucracy resulting in a considerable work for the Vycia Farm and Kaunas Energy Office. The consequence was that the trucks had to unload the cargo at the customhouse and return to Denmark. Meanwhile the cargo was in "No Man's Land", and the security in that the transport company is responsible for the cargo until the receiver signs for the reception, was partly annulled. On every new sending, the procedure for the declaration was changed from the Lithuanian customs side. The conclusion on this matter has been to send equipment only as few times as possible.

During the summer 1998, many construction activities were completed, and the site changed from a construction site full of activities to a new biogas installation. In September 1998, the final inspection of the digesters and the gasholder was carried out. The appearance was obviously improved, and the delivery from ICC was accepted. However, one reservation was registered concerning the agitators, because it was not possible to check them in operation. The result of an inspection later in September was that the agitator system could not be accepted due to misalignment of the shafts. This problem was corrected, and finally in October 1998 the delivery of the digesters could be finally accepted.

Picture 3-15 In September 1998 the final inspection of all deliveries from ICC was carried out. Everybody was satisfied with the fine result. On the picture is from the right, Preben Maegaard, Director, Folkecenter, Vygantas Pakalniskis, Commercial Director, ICC, J. Spudys, A. Leonavicius and Mr. Arturas from ICC, Alfredas Kontrimavicius, Cheif Engineer, Vycia and finally, on the left, Niels Ansø, Project Engineer, Folkecenter.

Picture 3-16 Folkecenter has currently informed the DEPA´s contact person and programme co-ordinator in Lithuania, Victorija Maceikaite. On the picture Folkecenters director, Preben Maegaard, informs about the progress in the implementation phase of the project and the soon coming starting up of the biogas installation.

The last major work in the implementation phase was the electric installations. Already in May 1998, the local utility company was visited to negotiate the permission for grid connection and to sell electricity to the grid. The utility company did not have knowledge about such equipment for decentralised power production, but as they were informed that the CHP units were standard equipment delivered with all grid protection facilities as required in Denmark and Germany, they were cooperative. They only asked for the documentation of these grid protection facilities in the interface between the CHP units and the grid.

The electricians from the Vycia farm carried out all the power installations. The work was co-ordinated with the Folkecenter who delivered the control system for the biogas installation. The control system was installed in September 1998. After that, only some of the electric installation for the manure pumps, agitators, and valves, for the heating control system remained.

By the end of October 1998, the main activities had been completed, and the installation was ready for start up. Nevertheless, one important task for the Vycia Farm was still remaining - the connection to the heating system of the stables, so the produced heat could be utilised and the heat expenses of the farm could be reduced. The most immediate connection to the nearby slaughterhouse was made in February 1999.

The starting-up phase began by starting the 1st digester. In parallel the last tasks in the implementation phase was carried out.

The installation of the CHP units awaited sufficient amount and quality of the biogas production. This happened in order to utilise this relatively expensive part of the installation costs most efficiently, and not to spend the guarantee period of the units before there was sufficient biogas for constant operation.

The CHP units were ordered by the end of May 1999 and sent to Lithuania by the end of July. They were delivered to the Vycia farm in the beginning of August, and finally set into operation in the beginning of November 1999. The long time for the installation and starting up was mainly caused by the delayed start of the installation work at the Vycia farm, and later on, by an accidental overfeeding of all 3 digesters which caused collapse of the biogas production. The collapse of the biogas process happened just before the planned travel to Lithuania for the supplier of the CHP units, and thus caused an additional 1 month delay since starting up was impossible in the absence of a sufficient biogas production.

Picture 3-17 It was an important and long awaited event when the CHP units were set into operation. On the picture is from the left Mr. Raimondaz Marma, Vycia, Mr. Johann Hochreiter, supplier of CHP units, Kazys Cesnavicius, Director Vycia, Mr. Alfredas Kontrimavicius, Vycia, and Mr. Juozas Savickas, LEI.

3.1.5 Starting up

By the end of October 1998 the first manure was filled into the 1st digester. $20m^3$ of grafting material from a brewery wastewater biogas installation was added. The oil boiler supplied the process heat. At the visit by the end of October, the general attitude of the Lithuanians was rather pessimistic regarding the obvious wish to have biogas production before the planned inauguration on the 13th of November. This mood changed thoroughly when the gas meter started to count - the first biogas production after long and hard efforts.

Picture 3-18 Only a few days after the 1st digester was filled with manure and grafting material, the first biogas flowed in the pipes. On the picture the inflammability of the gas is tested with a hastily constructed torch. It was obvious that it was biogas, but still the quality was too poor to burn.

The process accelerated fast and the biogas quality soon improved so it was possible to burn it in the gas boiler already before the inauguration, and the biogas process became self-supplying with heat.

It was a great day when the finalisation of the installation and the start up of the biogas process was celebrated with the official inauguration on the 13th of November 1998. The Vycia Farm had prepared and organised this event very well and professionally. Approximately 70 invited guests showed up, counting officials, politicians, researchers, suppliers, employees, and several representatives from newspapers and television. The interest for the biogas installation was great, and the informations were communicated widely in the media's.

Picture 3-19 The director of the Vycia Farm, Kazys Cesnavicius, welcomes all the guest at the inauguration and opens up for the many speeches.

After the successful starting up of the first digester, Folkecenter expected that the 2 other digesters were started up, but the Vycia farm was more reluctant on this matter. Vycia claimed that they wanted to do their own experiences with only one digester before starting the 2 other digesters. Folkecenter found it more obvious to produce as much energy as possible for the winter. The second digester was started in January 1999, and the third digester was started in April.

In March 1999, Mr. Karl Erik Jensen visited the biogas installation in order to give his experiences concerning operation and optimisation of the biogas plant. Mr. Jensen has 15 years of experience from a smaller Danish community biogas plant. The Lithuanians had now realised that biogas installations do not operate automatically without problems before everything has been turned into routines. The Lithuanians had many questions to Mr. Jensen based on their first experiences. Mr. Jensen answered the questions, commented other things he observed, and noticed that the biogas plant was ready to use - it just had to be used.

During the winter, the produced heat was utilised in the slaughterhouse but not in the stables. Therefore even from the moderate biogas production of 1100-1200 m^3 biogas / day, there was a surplus of heat, and surplus gas was burned in a torch. The mentioned biogas production was obtained from the manure and only a little amount of waste from the slaughterhouse. It indicated that the manure was better than expected even though the changes in the stable system in order to reduce the dilution of the manure were not completed.

It was the Folkecenter policy, that Lithuanians should do all the experiments with the gas production necessary in the efforts to raise the gas production. This practise would be very valuable when the CHP would be installed.

Still Folkecenters optimism was met with an incomprehensible hesitation from Lithuanian side. It was suggested that the motivation for producing more biogas was missing as long as the energy could not be utilised. As a result it was decided to purchase and install the CHP units before the first goal to have a reliable biogas production of 1700-1800 m^3 biogas / day was reached, which was sufficient for operating the CHP units around the clock.

The machine for chopping waste from slaughterhouses and tanneries was installed at the central mixer tank for all the 3 digesters. It meant that the planned separation and independent operation of the 3 biogas processes was not possible even though it had always been considered and mentioned as very important. The idea was that 1 digester could work as a reference digester on pure manure. The two other could work with different waste additives, and the result would be directly comparable. Nevertheless, all 3 digesters were filled with the same mixture of manure and waste, which on the first hand meant that there was no reference, and secondly, there was a risk to feed all the digesters with material that could harm the biogas process. This was exactly what happened at the end of September 1999, just before the planned starting up of the CHP units. The digesters were all supplied with a too strong mixture of manure and fatty waste. It resulted in all 3 digesters being stopped, and they needed a long time to recover. If only one digester had still been healthy, the 2 other digesters could easily and quickly have been recovered by emptying the hampered digesters and filling them again with fresh manure and grafting material from the healthy digester.

3.1.6 Information activities

Some information activities were carried out during the preparation and implementation phases of the project, but information activities have mainly been carried out after starting up of the biogas installation in November 1998. At this occasion, an information leaflet was prepared in both English and Lithuanian, and 6000 postcards were produced. Press releases were also sent out in November 1998, and the information material was presented on the Internet as well.

The project has been presented at several international conferences and seminars. There have been several local seminars in Lithuania, and many visitors have visited the biogas installation. Students from the Lithuanian University of Agriculture have possibilities to visit the biogas installation, and for the time being 4 students are working on projects related to the biogas plant at Vycia.

Researchers at the Lithuanian Energy Institute are involved in the operation and optimisation of the biogas plant. They also bring visitors, and the results from the biogas plant are used in their work as advisors in the field of Lithuanian energy policy.

A more detailed list of information activities is given in Annex E.

3.1.7 Follow up

The result of the implementation period was a complete high efficient biogas installation ready to use. Experiences with other biogas installations show that the full biogas production is achieved after 1-2 years of operation. Since starting up of the biogas installation, follow-up activities have been carried out. Folkecenter is still following the project and plans to continue this also in the future, to insure the best results under the local conditions. The positive attitude from the Danish side has been met with a not always understandable sceptical attitude from Lithuanian side.

The installation is completed and ready to use, but naturally the technique has to be fine adjusted, and many activities in the daily operation have to become routines.

The main efforts in the follow up-phase has been to encourage the Lithuanians to work actively with the implementation of routines, optimising the process, and utilising the energy. Besides, many questions have been answered.

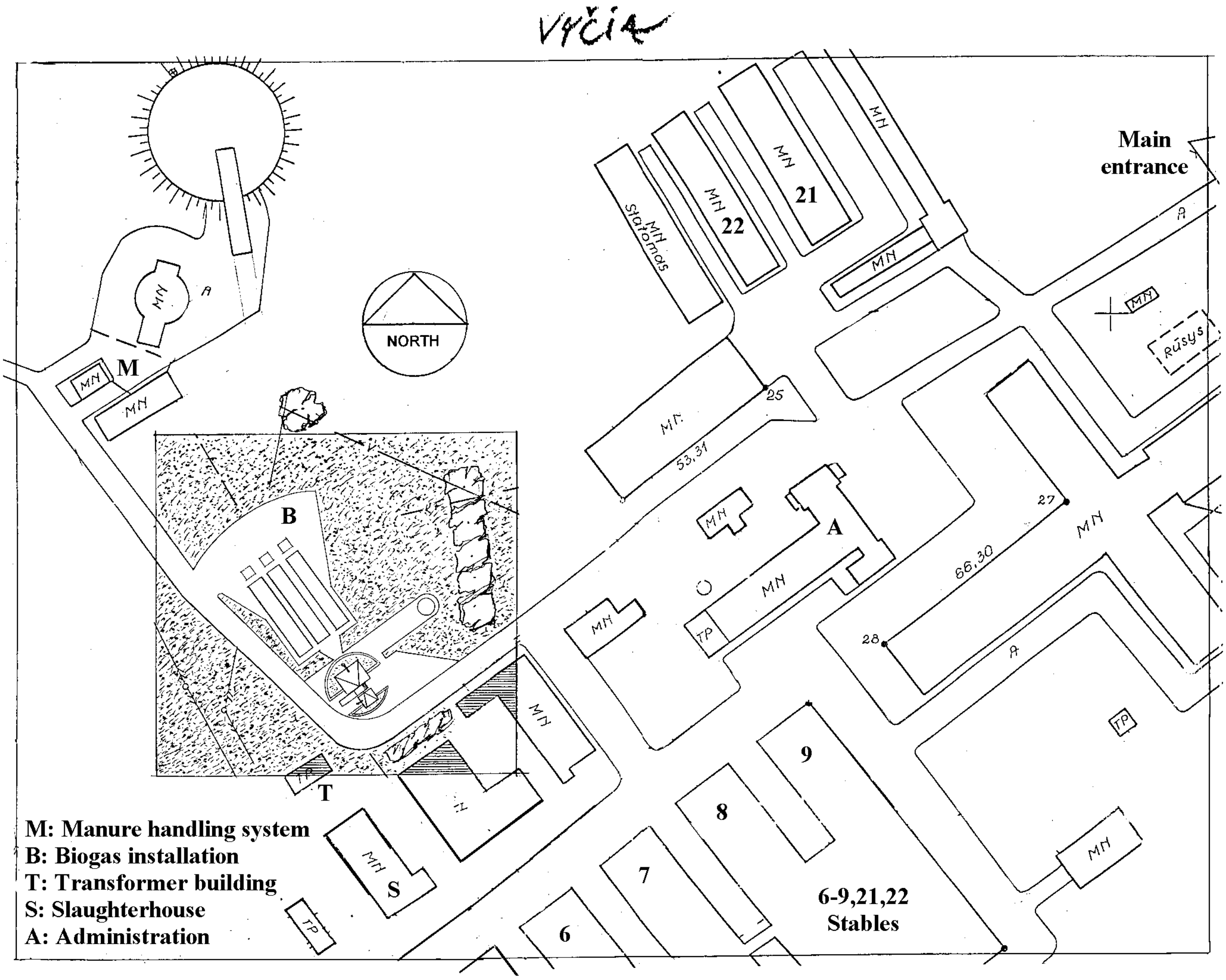
The efforts have been met with problems and delays mainly owing to organisational and cultural obstacles. In Denmark usually one person is co-ordinating all work and operation of a biogas plant, but in Lithuania many persons are involved with different responsibilities, and the overall leadership is difficult to identify.

In the future visits to Lithuania by Folkecenter staff and external consultants are planned for the purpose of assisting in the organisation of the operation and optimisation of the biogas plant.

3.2 Description of the biogas installation

3.2.1 The Vycia farm

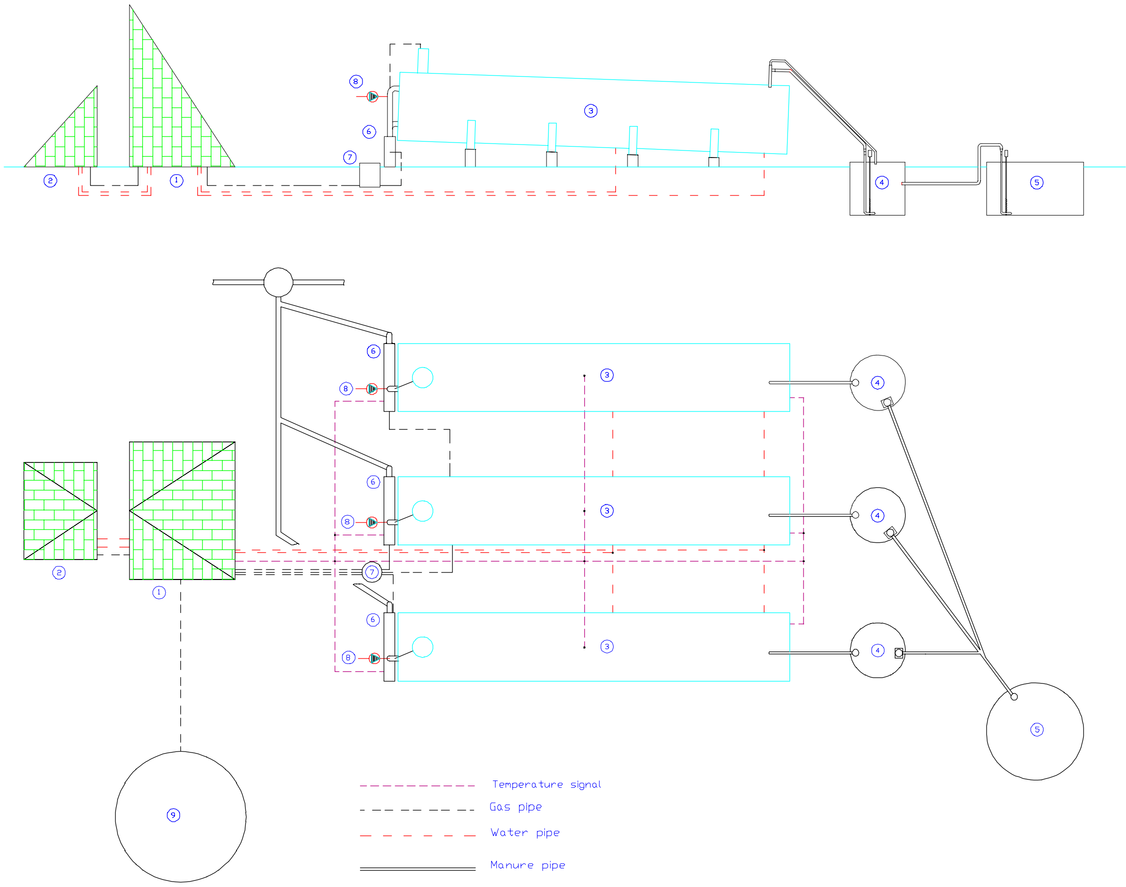
The Vycia farm is a former co-operative farm, which has turned into a private enterprise. There are about 100 employees including administration, veterinarians, slaughterhouse staff, and staff for the 5 butcher shops in Kaunas city. There are about 1000 sows and 10.000 porkers in the stables. The farm is situated Rokai approximately 15 km outside Kaunas. (See map of location on page 3)



Picture 3-20 Diagram showing the Vycia farm with situation of the biogas plant as the turning point between the main entrance and the manure handling system.

3.2.2 Digesters

The biogas plant consists of 3 horizontal digesters in a parallel configuration - fed by the same raw material - the manure. This gives unique possibilities to obtain continuous local experiences in the operation of the plant. Different additives and conditions of operating can be tested, and the results can easily be compared.



Picture 3-21 Schematic drawing of the biogas plant:
1) Technical building, control room, show room, laboratory and boilers. 2) Technical building, CHP´s. 3) Digesters. 4) 30 m^3 mixing tank. 5) 150 m^3 manure tank. 6) Manure outlet / sulphur cleaning system. 7) Condensate separation. 8) Air pump. 9) Gas holder.

Each digester has a volume of 300 m^3, totalling 900 m^3, which correspond to the capacity necessary for digesting the daily production of 60 m^3 of manure.

Picture 3-22 A view of the agitator inside a digester. In the foreground is the beam and the oakwood bearing carrying the agitator. On the picture it is still possible to enter through the opening prepared for the sand outlet in the bottom of the digester. Later on, the only way to enter is with a 5 metres ladder through the manhole in the top of the digester. The manhole is seen faintly as a light area in the background of the picture.

Each digester is equipped with 2 slowly rotating horizontal agitators which keeps the manure mixed and homogeneous. The low capacity motors of only 1 kW work in interval operation, e.g. 2 minutes

ON and 10 minutes OFF. Except for the agitators and their supports, the digester is completely empty and smooth inside, which allows no sedimentation and blocking of the flow.

Approximately 25% of the external surface of the digester body is covered with heating channels containing hot water. This keeps the digester at the right process temperature. The whole digester is insulated with 200 mm mineral wool and finally covered with weather protected aluminium coated steel sheets.

The digesters have a 2° inclination in order to guide sediment to the lower end at the manure inlet, and to guide the biogas to the upper end at the manure outlet. Sand and other sediments can be taken out through 2 sand outlets under each digester. The biogas ascends through the gas dome at the top of the digester.

Picture 3-23 Mixer tanks and manure inlet. At the end of the digesters are the motors and gears for the agitators.

Picture 3-24 The manure and gas outlet of the digesters.

See Annex G for more detailed drawings of the digesters.

3.2.3 Technical buildings

A remarkable design of the technical buildings was chosen to catch attention for this first biogas demonstration plant in Lithuania.

Picture 3-25 The smaller building contains the relatively noisy CHP´s. The ground floor of the other building contains boilers and other technical equipment, and the first floor contains laboratory, control system and functions as demonstration area.

Picture 3-26 The director of the Vycia Farm, Kazys Cesnavicius (left) and Cheif Engineer, Alfredas Kontrimavicius on the first floor of the larger building. They enjoy the result.

3.2.4 Manure system

The manure is taken from the stables to the central manure tank, from where it is distributed to the 3 mixer tanks at the digesters. In these mixer tanks different organic wastes can be added and mixed individually. From the mixer tanks the manure is pumped in sequences into the digesters, e.g. 3-12 times per day. When pumping manure into the digester, an equivalent volume is displaced through the manure outlet by a simple overflow principle.

See Annex G for a more detailed diagram of the manure system.

3.2.5 Organic waste treatment system

The biogas installation is equipped with a chopping machine for pre-threading solid waste with long and stringy structure, e.g. waste from slaughterhouses and tanneries. The Vycia farm has prepared a receiving station in connection with the chopping machine, so trucks and tractors can unload the waste into a hydraulic activated dump body for feeding the machine.

Picture 3-27 Algis Lukosevicius in front of the chopping machine and the hydraulic activated dump body.

3.2.6 Gas system

The gas ascends from the gas dome situated in the upper top end of the digester. From the digester it is led into the technical building where the production from each digester is registered individually through flowmeters. The 3 lines are sampled into 1 common pipeline leading to the boilers, CHP´s and the gasholder. The weight of the gasholder creates a counter pressure in the system, sufficient for operating the boilers and CHP´s without any additional energy consuming equipment such as a compressor. See Annex G for a more detailed diagram of the gas system

3.2.7 CHP units

2 CHP units with capacities of $75kW_{el}/122kW_{heat}$ and $110\ kW_{el}/178kW_{heat}$ respectively have been installed. This configuration was chosen in order to get a more flexible solution with respect to maintenance and fluctuating gas production. Each CHP is delivered with a complete control system including grid protection and grid connection.

The engines are of the dual fuel type, which means that they are standard diesel engines modified to run on a combination of diesel and biogas. 5% diesel creates the basis and the ignition of the combustion. Biogas is mixed with inlet air to the engine and increases the output power from 5% to 100% of nominal capacity. The technology is simpler and cheaper compared to specially manufactured gas engines. The diesel engines are standard tractor engines, which are familiar to farmers and mechanics. When the engine is worn out, it is rather simple and relatively cheap to replace it by a new engine.

The dual fuel technology is less sensitive to fluctuating gas quality. When gas engines have difficulties in starting and running on gas qualities very different from the optimised composition, dual fuel engines always starts with the liquid fuel, and together with the natural surplus of oxygen for diesel type engines, even biogas with pure methane contents can be combusted.

The 2 CHP´s at the Vycia farm are equipped with automatic power regulation which means that the engines are automatically regulated to maintain the chosen power output, even if the gas composition changes.

It is technically possible to modify the engines to use a CO_2 neutral fuel such as vegetable oil instead of diesel for the ignition fuel.

3.2.8 Boiler

There are 2 boilers, each one of 300 kW capacity. One is equipped with a gas burner, which can utilise the surplus gas exceeding the consumption of the CHP´s, and the whole gas production when the CHP´s are stopped for maintenance. The other boiler is equipped with an oil burner, which can supply the process heat when starting up the biogas process first time after a stop. The oil burner can be changed into a gas burner if it proves advantageous in the future.

3.2.9 Heating system

The waterborne heating system supplies the biogas process with heat from the boilers and CHP´s. Excess heat is pumped to the Vycia farm’s heat consuming facilities such as slaughterhouse, administration building, and stables. For summer operation, excess heat can be ventilated to the free though the dump-load calorifiers which are an integrated part of the CHP´s.

See Annex G for a more detailed diagram of the heating system.

3.2.10 Laboratory equipment

The biogas plant is equipped with instruments for measuring simple indicators used for the daily operation and optimisation of the biogas process. For measuring the amounts of solid and volatile matter in the manure and the organic wastes, a scale, a kiln, and a furnace, are used. A pH-meter is used for measuring the pH value of the biogas process and the motor oil from the CHP´s. A gas sample pump is used for measuring the H_2S and methane contents of the biogas.

3.2.11 Control- and data acquisition system

A PC equipped with extension cards forms the heart of the control and data acquisition system. Temperatures are measured at 8 positions in each digester and directly used for controlling the supply of process heat. The gas production is measured individually from each digester, and together with measuring the position of the gasholder, the actual consumption can be determined. The computer controls the agitators and valve actuators for the process heat supply. The system is prepared for automatic control of boilers, CHP´s, feeding of manure to the digesters and has several extension possibilities. The electric production from the CHP´s is measured as well.

See Annex G for a diagram of the Control- and data acquisition system.

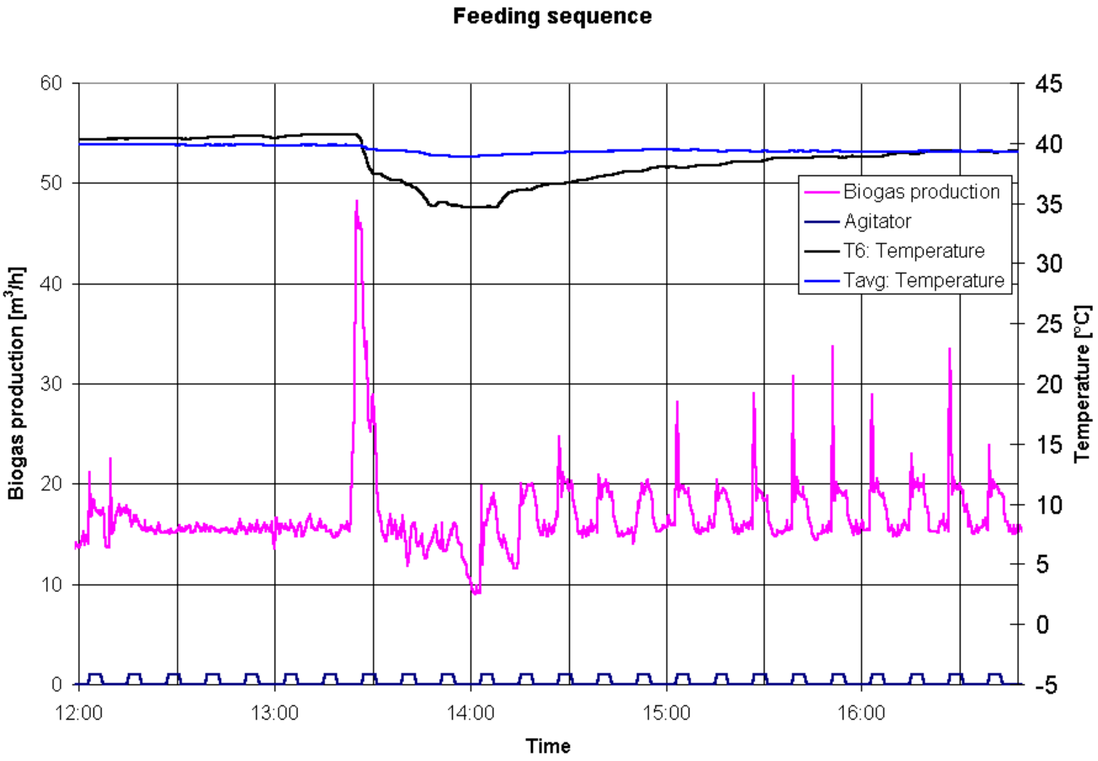


Figure 3-1 The figure above shows a feeding sequence generated from stored data. The control of the agitator is shown in the lowest jagged curve, and the activity of the agitator is recognised by fluctuating gas production following the same time sequence. Nevertheless, this activity is not recognised in the gas production from 12:15 to 14:00 because the operation of the agitator has been set into manual mode. At 13:26 fresh cold manure have been pumped into the digester. It is recognised both in the rise of gas production and in the temperature drop of T6 in the digester, which is situated close to the manure inlet. After 14:00 the agitator has been set into automatic operation.

All values are monitored through a graphical interface and values are saved every ½ minute for later analysis. The system is flexible for future changes for which local expertise is available.

See Annex G for a more detailed diagram of the control- and data acquisition system.

3.3 Results

The most concrete result of the project is the installation, running in, and operation, of a biogas plant matching the amount of manure and energy demand on the larger pig farm Vycia. The biogas produced on the plant is utilised in CHP´s producing electricity to the grid and heat for domestic use at the farm. Through the anaerobic digestion, the manure is converted into a more ready-to-use fertiliser. A more detailed description of the biogas installation is found in chapter 3.2.

3.3.1 Education

Direct educational activities have been carried out in connection with the training activities. These activities are described more detailed in chapter 3.1.2. The implementation phase has been one long training period with maximum focus on technology transfer and local production.

More indirect educational activities have been carried out by derived activities. For example, several students on Kaunas University of Agriculture have performed projects related to the present project; presently, 4 students are at work.

3.3.2 Information

Informations about the present project have been disseminated through leaflets, postcards, Internet, press releases, articles, and television. The project has been presented at several national and international seminars and conferences as well. A more detailed list of the information activities are given in Annex E , information activities.

Enthusiastic people, who have put great efforts into the present project, are using the biogas project as a reference and for inspiration in their daily work as teachers, researchers, advisors, politicians etc.

3.3.3 Production data

The following is a review of the production data from the biogas plant between April 1999, when all 3 digesters were set in operation, and February 2000.

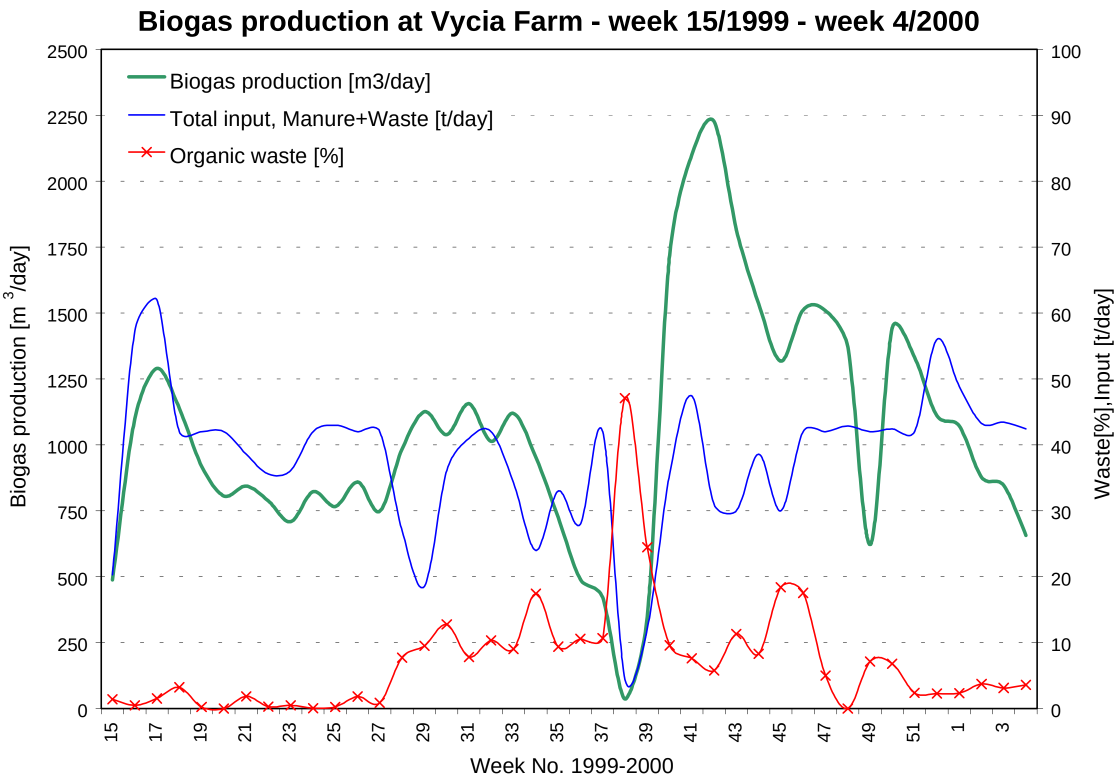


Figure 3-2 The figure shows the daily amount of biogas production, total input of manure and organic waste, and the percentage of organic waste in the fed material. Both the amount of fed material and the percentage of organic waste are fluctuating significantly, and this is recognised in the gas production. In week 38 all the digesters were overfed with strong fatty waste, so the biogas production dropped to nearly zero followed by a very high production when the process recovered. The figure also shows that the system has potential for a much higher biogas production, but initiatives for more constant and higher supply of manure and organic waste have to be taken. The data are given as numbers in Annex H, Production data.

All experience in biogas technology shows that a stable operational conditions with only smooth changes in the amounts and composition of the manure and organic wastes form the most important prerequisite for a high biogas production.

The most obvious remark to Figure 3-2 is that the supply of manure and organic wastes has been unstable. The result is a fluctuating biogas production, which is below the expected level. In addition, the present supply is much lower than the capacity.

The biogas plant has been supplied with a daily average of 35,7 tons manure and 2,1 tons organic wastes, totalling 37,8 tons of biomass. This makes only 63% of the capacity of the digesters, which is 60 tons per day. The 35,7 tons manure per day corresponds well to the theoretical figure calculated by the Danish agriculture expert Ivar Ravn. He has calculated 34,7 tons per day from the 5 stables that have supplied manure to the biogas plant until now.

Another group of 5 stables is in a suitable condition, but the manure from these stables is still bypassed the biogas plant, because of outstanding technical problems with the manure supply system. The amount of manure from these 5 stables is calculated to be 14 tons/day, which forms the basis for raising the amount of processed manure with 40% to a total of 48,7 tons/day. With up to 10% of organic wastes, the total supply of biomass may reach 53,5 tons/day or about 90% of the capacity.

The remaining stables at the farm would require a more thorough modification before they could be included in the manure supply system, but there is still room for a further extension.

The average daily biogas production throughout the period has been 1042 m^3/day, which corresponds to a yield of 27,6 m^3/ton biomass; according to Danish experience, this is a moderate figure for manure without additional organic wastes.

On corresponding Danish biogas plants fed with a combination of manure and organic wastes, the yield per ton biomass is at least twice as high, when constant and stable operational conditions are upheld. The importance of stability is well established: Danish experience shows that the yield per ton biomass may vary within a factor 3 on identical biogas plants.

The extensions mentioned above will result in a significant increase in the organic basis for the biogas production, and the efficiency will be increased considerably by upholding stable operational conditions.

Consequently, there is every reason to expect a much higher future production at the plant than the hitherto production figures. In this connection it should be noted, that the average production so far is only slightly below the nominal value of 1200 m^3/day defined prior to the project.

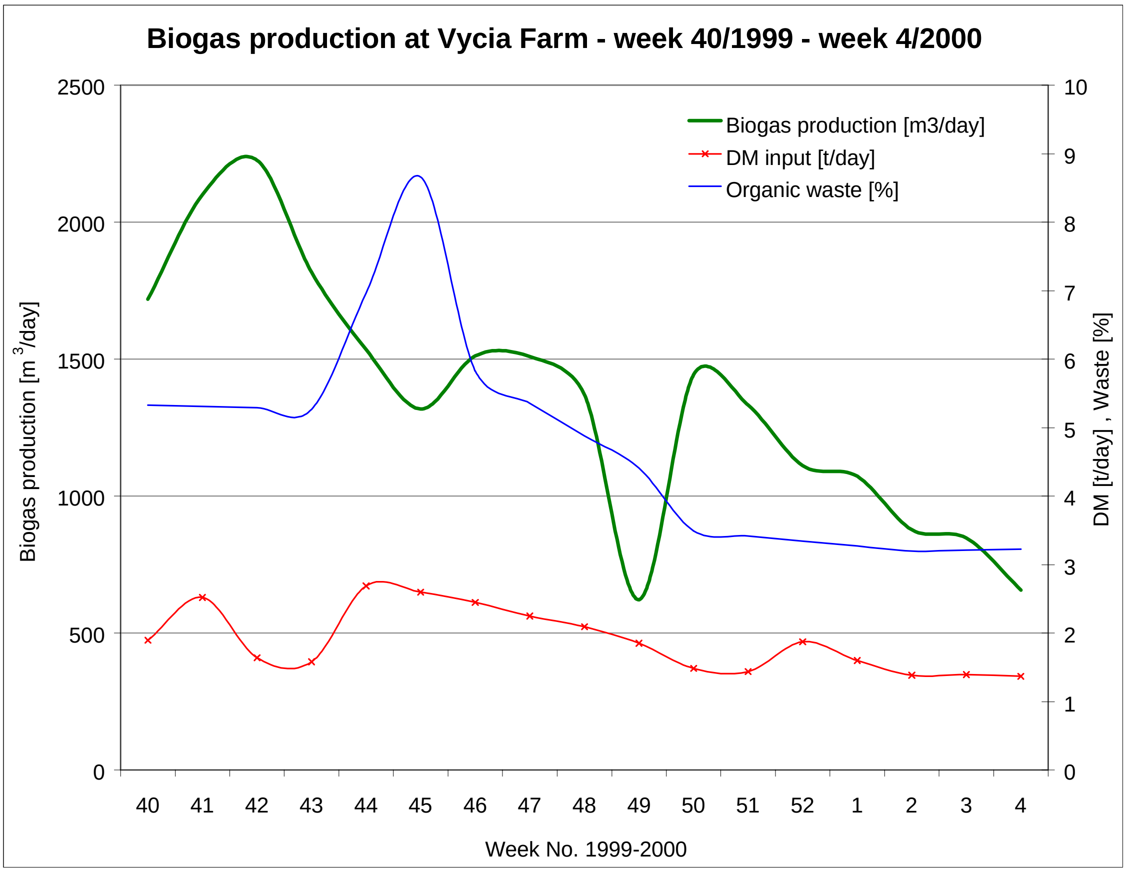


Figure 3-3 The figure shows the decreasing tendency of the biogas production when the supplied amount of Dry Matter(DM) and the percentage of organic waste drops.

3.3.4 Estimated production figures

The basic daily biogas production of 1200 m^3 corresponds to 50 m^3 per hour, and the potential daily biogas production of 3600 m^3 corresponds to 150 m^3 per hour. A moderate intermediate biogas production of 2400 m^3 per day corresponds to 100 m^3 per hour.

The following table 3.3.4.1 shows the production figures for the different energy production units:

Unit	Consumption		Production	
	m^3 gas/hour	m^3 gas/day	Heat, kW	Power, kW
300 kW Boiler unit	50	1200	300	-
110 kW CHP unit	50	1200	178 *)	110 *)
75 kW CHP unit	35	840	122 *)	75 *)
Total capacity, all units	135	3240	600	185

Table 3.3.4.1: Production figures **): 95% from biogas, 5% from ignition oil*

As it appears, the nominal biogas production is sufficient to run either the large CHP unit or the boiler unit continuously; alternatively, the small CHP unit may be run continually with intermittent operation of the boiler unit 30% of the time. A moderate production is sufficient to run both CHP units continually, and the potential biogas production is more than sufficient to run all present units continuously.

With a conservative estimate, the annual number of operation hours is 8.000 for a primary unit. The annual number of operation hours for a secondary unit is 600; this corresponds to 80% of the remaining time.

The effective production figures in kWh/year are found by multiplication of production by number of operation hours.

In the following subsections, gross and net energy productions are calculated at basic, moderate, and potential, biogas production respectively.

In the calculation of net power production, the power generated by ignition oil is excluded; according to the CHP specification, this amounts to 5% of the capacity.

In the calculation of net energy production, the process heat and power is excluded; according to Danish experience, the amount of process heat corresponds to heating the manure from 10- to 40°C. 60 m^3 of manure per day corresponds to a constant heat consumption of 90 kW. With an extra 10% of biomass, the heat consumption at the potential biogas production is increased to 100 kW. The process power in general is very low. At the present biogas installation it is calculated to a constant power of 3kW.

As it appears, the present system can yield a net energy production in the range of 1550 - 5050 MWh/year. With a seasonal variation and a moderate average corresponding to a net production of 3750 MWh/year, the present system can match the energy consumption throughout the year, in both amount and distribution.

With an extension of the power capacity, the potential net energy is increased to 5900 MWh/year. This production would yield a surplus of energy, primarily power, for sale.

3.3.4.1 Basic biogas production:

The effective production figures with maximum power production are shown in the following table 3.3.4.1.1:

Unit	Priority	Operation hours/year	Effective Production, kW		Annual production, MWh	
			Power	Heat	Power	Heat
300 kW Boiler	Secondary 30%	200	-	300	-	60
110 kW CHP	Primary	8000	110	178	880	1424
75 kW CHP	Secondary	600	75	122	45	73
Total, gross					925	1557
Reduction for process power and heat		8760	-3	-90	-26	-788
Reduction ignition oil 5 %					-46	-78
Total, net					**853**	**691**

Table 3.3.4.1.1: Energy production from basic biogas production.

As it appears, the basic biogas production yields a gross energy production of about 2500 MWh/year and a net energy production of about 1550 MWh/year. The approximate distribution between power and heat is 55/45.

With this, the basic production is able to provide about 43% of the present energy consumption at the farm, which is 3700 MWh.

3.3.4.2 Moderate biogas production:

A daily biogas production of 2400 m^3 corresponding to 100 m^3 per hour is sufficient to run both CHP units as primary units with intermittent operation of the boiler unit in 30% of the time. The effective production figures are shown in the following table 3.3.4.2.1:

Unit	Priority	Operation hours/year	Effective Production, kW		Annual production, MWh	
			Power	Heat	Power	Heat
300 kW Boiler	Secondary	600	-	300	-	180
300 kW Boiler	Primary 30%	2400	-	300	-	720
110 kW CHP	Primary	8000	110	178	880	1424
75 kW CHP	Primary	8000	75	122	600	976
Total, gross					1480	3300
Reduction for process power and heat		8760	-3	-90	-26	-788
Reduction ignition oil 5 %					-74	-165
Total, net					**1380**	**2347**

Table 3.3.4.2.1: Energy production from moderate biogas production.

As it appears, the moderate biogas production yields a gross energy production of about 4800 MWh/year and a net energy production of about 3750 MWh/year. The approximate distribution between power and heat is 37/63.

This production is very close to the amount and distribution of energy consumption at the farm, which are 1400 MWh of power and 2300 MWh of heat with a total of 3700 MWh.

Furthermore, the system is well suited to a flexible operation where the amount of organic waste and thus the production is adapted to the seasonal variations in heat demand.

A well planned variation within the range from the basic biogas production of 1200 m^3 per day to the potential 3600 m^3 per day with an average daily biogas production of 2400 m^3 would match the energy consumption at the farm throughout the year.

3.3.4.3 Potential biogas production:

A daily biogas production of 3600 m^3 corresponding to 150 m^3 per hour is more than sufficient to run all present units as primary units. The effective production figures with the present units are shown in the following table 3.3.4.3.1:

Unit	Priority	Operation hours/year	Effective Production, kW		Annual production, MWh	
			Power	Heat	Power	Heat
300 kW Boiler	Primary	8000	-	300	-	2400
110 kW CHP	Primary	8000	110	178	880	1424
75 kW CHP	Primary	8000	75	122	600	976
Total, gross					1480	4800
Reduction for proces power and heat		8760	-3	-100	-26	-876
Reduction ignition oil 5 %					-74	-240
Total, net					**1380**	**3684**

Table 3.3.4.3.1: Present units.

As it appears, the potential biogas production yields a gross energy production of about 6300 MWh/year and a net energy production of about 5050 MWh/year with about 27% power and 73% heat.

Obviously, a continuous production of this magnitude calls for an extension of the CHP capacity, which could be financed by the corresponding considerable sale of surplus electricity.

The effective production figures with extended power capacity are shown in the following table 3.3.4.3.2:

Unit	Priority	Operation hours/year	Effective Production, kW		Annual production, MWh	
			Power	Heat	Power	Heat
300 kW Boiler	Secondary	600	-	300	-	180
150 kW CHP	Primary	8000	150	240	1200	1920
110 kW CHP	Primary	8000	110	178	880	1424
75 kW CHP	Primary	8000	75	122	600	976
Total, gross					2680	4500
Reduction for process power and heat		8760	-3	-100	-26	-876
Reduction ignition oil 5 %					-134	-225
Total, net					**2520**	**3399**

Table 3.3.4.3.2: Extended power capacity.

As it appears, the extension would increase the gross energy production to about 7200 MWh/year and the net energy production to about 5900 MWh/year with about 43% power and 57% heat. This energy production would yield a significant surplus of energy, primarily power, for sale.

4 Project inputs

4.1 Staff involved in project

4.1.1 Danish side

Folkecenter staff
Mr. Preben Maegaard, Director
Mrs. Jane Kruse, Information & Training Programmes
Mr. Niels Ansø, Engineer
Mr. Oliver Blome, Engineer
Mr. Lars Chr. Christensen, Engineer
Mr. George Abogaye-Mathiesen, Ph.D, Biochemist
Mrs. Lisbet Christensen, Agronomist
Mr. Jacob Bugge, Senior Consultant

External consultants
Mr. Ivar Ravn, Managing Advisor for Farm Construction, Morsø Agricultural Advisory Center
Mr. Ernst Breum, Engineer, Advisory Engineering Company, Per Kristensen
Mr. Erwin Köberle, Engineer, Biogaskontor Erwin Köberle

4.1.2 Lithuanian side

Lithuanian Energy Institute, LEI
Mr. Juozas Savickas, Senior Research Associate, Lithuanian Energy Institute, LEI.
Mr. Arturas Klementavicius, Research Associate, Lithuanian Energy Institute, LEI.

Vycia farm
Mr. Kazys Cesnavicius, Director, Vycia Farm
Mr. Alfredas Kontrimavicius, Chief Engineer
Mr. Mr. Liudas Staras, Financial director
Mr. Raimondaz Marma, Chief Electrician
Mr. Algis Lukosevicius, Electrician, Operator of the biogas plant at the Vycia Farm

External consultants
Mr. Kestutis Navickas, Assoc. Prof., dr., Lithuanian University of Agriculture, Department of Agro-energetics
Mr. Gintaras Dervinis, Engineer, Assoc. Prof., Kaunas University Of Technology
Mr. Mindaugas Stalnionis, Engineer, Kaunas Energy Office

4.2 Procurement summary

The following list shows a wide range of the main components purchased for the biogas installation.

Item	Purchased	Produced origin
Digesters		
Digester tanks with insulation	LT	LT
Aluminium coated steel plate for insulation	DK	S
Gear motors for agitators	DK	I
Couplings for agitators	DK	
Manure valves	LT	RU
Manure system		
Manure pumps	DK	DK, etc.
Water valves	DK	DK, etc.
Manure pipes	LT	DK
Actuators for manure pumps	DK	CH
Concrete tanks	LT	LT
Organic waste treatment system		
Meat chopper machine	DK	DK, etc.
Equipment for waste receiving station	LT	LT, etc.
Gas system		
Piping	LT	RU
Gasholder	LT	LT, etc.
Concrete tank for gasholder	LT	LT
Sulphur cleaning	LT,DK	DK,D, etc
Gas counters	DK	D
Active coal	DK	D,etc.
CHP units with control system	D	D, etc.
Transformer, grid connection for CHP´s	LT	RU
Buildings, 2 technical buildings	LT	LT
Heating system		
Boilers	DK	DK
Burners for boilers	DK	I, etc
Piping for heating system	LT	LT,RU,I, etc.
Pumps for heating system	DK	DK
Valve and valve motors for heating system	DK	DK
Laboratory equipment		
Scale, pH-meter, sample pump for gas, test pipes for gas	DK	D,J, etc.
Control- and data acquisition system		
PC, computer	DK	mixed.
Computer Interfaces Cards for Measuring and control	DK	USA
Control box, interface for biogas control	DK	DK,etc.
Temperature censors, level censor	DK	DK,etc
Switches, relays, cables, etc.	LT	S, RU

5 Financial statement

The financial statement concerning the Danish funding is presented in the annual statements of accounts and the final statement of accounts covering the entire project period. These statements form Annex A , financial statement, Danish funding.

As it appears, the accounts correspond strictly to the budget, and the whole set of accounts has been audited by the state authorised accountant of Folkecenter as stated with the signature on the final statement of accounts.

The financial statement concerning the Lithuanian cofunding as received from Vycia is presented in Annex B, financial statement, Lithuanian funding.

6 Project sustainability

The sustainability depends directly upon the actual energy production. This applies to both the environmental and the economical aspects.

As it appears from items 1, 2.1.3, 3.1.7, and 3.3.4, the potential energy production exceeds the nominal production by a factor 3. At the same time, the actual production depends entirely upon the operational conditions, including the current amounts of organic material fed into the system.

Since the responsibility for the plant rests entirely with the VYCIA Farm, and since the project has successfully demonstrated the prospects, it is reasonable for the purpose of this report to presuppose an energy production in the range between the nominal figure and the demonstrated potential.

The moderate biogas production of 2400 m^3 from 60 m^3 of manure per day is the median of the range. Furthermore, the corresponding energy production calculated in section 3.3.4.2 matches the amount and distribution of energy consumption at the farm.

For these reasons, the description in the following subsections is based upon the estimated net energy production stated in section 3.3.4.2, which is 1400 MWh of power and 2350 MWh of heat with a total of 3750 MWh, which directly substitutes 3750 MWh of power.

6.1 Environmental sustainability

As it appears from section 7.1, the total estimated reduction in CO_2 equivalents obtained through the project is 5746 t CO_2/year.

In addition to this, the high contents of volatile solids in the raw manure are converted to more stable organic matter with a higher value of the manure as a fertilizer. This may form the basis for a considerable reduction in the groundwater pollution, primarily with nitrates.

6.2 Economical sustainability

According to Annex I, electricity prices for the Vycia farm, the present average electricity price for VYCIA is 0,16 LTL/kWh or 160 LTL/MWh. With the present exchange rate of 1 LTL = 1,90 DKK, this corresponds 300 DKK/MWh. The ordinary consumer price is higher.

The figures apply to both selling and buying, so the values apply to the total energy production which substitutes power, and the total amount may be regarded as a direct income.

The value of the estimated energy production is 160 x 3750 = 600.000 LTL, or 300 x 3750 = 1.125.000 DKK. Maintenance work on motors are expected to be 40 DKK / MWh produced power which gives a total of 60.000 DKK / year. The annual net income from the energy production is 1.065.000 DKK

Compared to the total project budget of 4.440.000 DKK, the simple payback time is 4,2 years.

For new biogas plants established commercially on the basis of this project, there will be no extra expenses related to the learning process and the experience building involved in the introduction of a new technology, which were part of the project. On the other hand, a commercial price must include risk and profit.

The total manufacturing costs in the project have been 3.175.633 DKK. With an addition of 50% covering consultancy, risk, and profit, a realistic price estimate in the initial stage of commercial market development might be 4.763.450 DKK. Compared to this price, the simple payback time is 4,5 years.

As it appears, the extra expenses related to the technology aspect in the project seem to balance the commercial aspect, and the simple payback time is about 4 years in both calculations.

With a further biogas implementation and commercial market building in Lithuania, it is expected that the price of establishing a similar production capacity will be lower. The general experience is that an open competition between multiple suppliers leads to price reductions caused by a combination of expense optimization and reduced profit.

On this basis, it may be estimated that the payback time in an expanding commercial market in Lithuania will decrease from an initial 4 years.

7 Impact assessment

The impact of the project, like the project sustainability, depends directly upon the actual energy production. As explained in item 6, it is reasonable to presuppose a biogas production of 2400 m^3 from 60 m^3 of manure per day and a net energy production of 1400 MWh of power and 2350 MWh of heat with a total of 3750 MWh.

7.1 Environmental impact

The environmental impact consists of two pollution reduction contributions: environmental improvement of the manure handling system and substitution of traditional energy sources.

As it appears from the following subsections, the total estimated reduction in CO_2 equivalents obtained through the project is 5746 t CO_2/year. With a total Danish funding of 3.810.000 DKK, the key figure for the Danish funding is 1,50 kg CO_2/year/DKK. As a comparison, the key figures for the various national Danish energy support programmes ranged from 0,04 to 1,10 kg CO_2/year/ DKK in 1999 according to [*], page 14, table 4.

7.1.1 Manure system

Ultimately, the CO_2 emission is the same, with and without the biogas plant. According to [**], page 39, note 4, the reduction in methane emission obtained by processing the manure is 3.6 kg/m^3, and the equivalent amount of CO_2 is 19 times greater, 68 kg CO/m^3, or 0,068 t CO/m^3.

This reduction is caused by the fact that a certain amount of methane is developed in the manure even without the biogas plant, and that this methane (CH_4) is emitted directly instead of being converted into energy, water (H_2O), and CO_2.

With 60 m^3 of manure per day, the annual reduction in CO_2 equivalents is 60 x 365 x 0,068 = 1489 t CO_2.

The amounts of laughter gas and other greenhouse gases have not been estimated.

7.1.2 Energy production

With the project, the net energy production of 1400 MWh of power and 2350 MWh of heat with a total of 3750 MWh substitutes an electricity production of 3750 MWh. This is caused by the fact that the present heating system is based entirely upon electrical heating.

The Ignalina nuclear power plant presents overwhelming problems in terms of safety and environment, and there are serious considerations about closing it down as soon as possible. For these reasons, it is appropriate to disregard the Ignalina plant as a comparable source of electricity production.

The most relevant source of electricity for comparison seems to be a coal fired power plant, which yields the lowest production prices among the fossil energy sources. A relatively high efficiency of 40% as presupposed in [**], page 18, note 3, yields a conservative estimate of the CO_2 reduction.

1 MWh equals 3,6 GJ. With an electrical efficiency of 40%, 1 MWh electricity requires a heating value of 9 GJ.

According to [***], page 5, diagram, the total amount of CO_2 equivalents per GJ of coal is 0,1269 t.

With this, the annual reduction in CO_2 equivalents from the substitution of 3750 MWh electricity is 0,1269 x 9 x 3750 = 4257 t CO_2.

---

[*] Energistyrelsens tilskudsordninger beskrivelser og vurderinger, Energistyrelsen 2000.
[**] Biogasfællesanlæg fra idé til realitet, Energistyrelsen 1995
[***] Større CO_2 fortrængning - fra biomasse, Dansk BioEnergi nr. 48, December 1999.

8 Recommendations

Based upon the experience, insight, and results, obtained in the project, certain follow-up actions are recommended.

At the Vycia farm

In the vicinity of the farm, there is a significant amount of unused land; approximately 200 ha are directly connected to Vycia. In addition, there is no present use for the processed manure.

An appropriate utilisation of this land could serve a number of purposes which would further strengthen the environmental impact of the project. With a production of fodder based upon the processed manure, the need to buy fodder produced on chemical fertilisers would be reduced. As part of this, rape seed could be included in a normal crop rotation with a five year cycle. An area of 40 ha could provide an annual production of 40 tons of cold-pressed rape seed oil which could replace the entire amount of diesel used in the CHP units; in addition, 80 tons of high-value fodder cakes would provide a valuable supply of protein and fat.

The training in Denmark of Vycia staff members has stimulated the interest for Danish agricultural practices.

It is recommended to perform a direct follow-up project in a cooperation between Folkecenter, Vycia, and leading Danish agricultural specialists to fulfil these purposes. Continuation of the well-established contact and cooperation between Folkecenter, Lithuanian Energy Institute and Lithuanian University of Agriculture is obvious as well.

Further biogas implementation

Hopefully, the present project will prove to be the first phase in a large-scale biogas implementation in Lithuania. The biogas plant at Vycia has attracted great interest in the technology and prospects demonstrated.

The next phase implies purely Lithuanian investments, probably on a commercial basis. A free consultancy service for new actors with direct access to Danish experience and expertise, including study trips and training in Denmark, could speed up the process and promote the transfer of technology and knowhow to a wide circle.

It is recommended to set up a consultancy service managed by Folkecenter with Kaunas Energy Office as a contact point in Lithuania.

9 Lessons learned

Especially during the implementation phase of the present project, it has been confirmed that knowledge and understanding of local culture and conditions are very important for a successful project. The Lithuanian society is still strongly influenced by its past as a former Russian republic. Nevertheless, the society is constantly and swiftly changing after turning into an independent state and under influence of the new connection to Western Europe.

Some experiences obtained by the present project can be useful either for easier or faster carrying out of future projects. Other experiences can be used for a more realistic planning of a new project. This point especially refers to the fact that everything takes longer time in Lithuania compared to Denmark, and also the present project has taken much longer time than planned. Many extra hours have been invested in the project because of unexpected problems.

9.1 Problems encountered

In the following, some examples of experiences learned by the present project are listed. The examples should not be understood as criticism but more as a statement of the given conditions.

Things take more time

Compared to Danish conditions, work carried out in Lithuania takes significantly longer time. It is difficult to point out the main reasons for this fact, but seemingly it is generally accepted that things take longer time. For example craftsmen’s work is usually done by more people than used for the same job in Denmark. If the work is not finished by the end of the normal working day, it will be continued the next day. In justice it should be said, that several times under the implementation phase, local people has worked after normal working hours in order to speed up the work, or to benefit of the presence of Danish experts, but still it is not with the same working enthusiasm as seen on a Danish workplace.

A typical example is a meeting concerning work that has to be done. The understanding between the participants is clear, there are no further questions. Nevertheless it may occur that nothing happens about the things agreed upon before it is discussed at the next meeting.

Organisation between the actors and drive from groups and individuals.

For larger jobs with many people involved, organisation is needed, and Lithuania is no exception. During the present project it has very often been experience that the communication between different demarcations, organisations, and even colleagues from the same workplace, has been very poor. It has been seen that one person has a question about something for which the man next to him knows the answer, but nobody talks about it even though it must be obvious.

The general organisation is based on respect to the hierarchy. If something is not within one’s authorisation, one is very careful not to take initiatives in that field. It may very well happen that one man can see what has to be done, but it is not his responsibility or he is not authorised to step in.

Several times work has been postponed during a long time because too many people are involved, but none of them goes into it actively and acts as a leader or a catalyst for the job that has to be done. Another explanation can be the question about taking responsibility or not.

General understanding and respect for "good appearance”

From time to time frustrations have come up caused by the general difference in the understanding and respect for what may be called good appearance. The most serious case on this matter was the long discussion about the appearance of the insulation work on the digesters. Without exaggeration, it may be claimed that the insulation work first presented looked very bad. Not only was the finish of the work poor, but also afterwards heavy ladders were rested against the insulation cover plates and caused dents in the surface.

Even after the insulation of the digesters had finally been concluded and accepted with very fine results, people walked on the unprotected top of the digesters. The insulation cover plate is supported every meter, but steps between the supports resulted in deep dents in the cover plate along one of the digesters. Fortunately, it was possible to straighten the plates again with a sucking disc, and footbridges were established.

Another example appeared after the boilers were installed with nicely painted cover and insulation plates. The construction work was still going on in the building, so when something high should be reached, the boiler was used as a landing to stand upon - without protecting the sensitive surfaces. Also when gas pipes were welded, glows and sparks had free access to burn marks in the plastic cover of the burners. A simple protection like a sheet of cardboard could have prevented this.

Always unexpected surprises
The above-mentioned experience about the dents in the cover plate of the digester is one of the unexpected surprises that occurred.

Another example is sudden changes to what was agreed and explained. Usually there is no explanation available afterwards.

The biogas process has first priority to the heat, thus there is a special heat string installed for this purpose with a circulation pump specially chosen to match exactly this task. Nevertheless 2 times, once during pipe installation and once after starting up, changes were introduced. Under the piping installation, the heat string to the farm was coupled in parallel with the process heat string, thus the process heat did not have first priority any more, but was totally dependent on the other system. The correct installation was clearly pointed out in the diagram, see Annex G, additional technical documentation. This problem was corrected in time, and could have been caused by a mistake. Under a visit to Lithuania in the follow up period, the operator of the biogas plants claimed that he couldn't keep the temperature up in the digesters. It was very surprising because the biogas plant had already been operated during one winter with no sign of undercapacity or malfunction. Suddenly it was revealed that the more powerful pump for the process heat was used for another purpose and replaced by a pump with lower capacity. This was the obvious explanation, but it ought not be necessary to have an expert travel all the way from Denmark to figure it out.

Priority of biogas production
During the project, the efforts to optimise the biogas production and utilise the facilities for monitoring and experience building have sometimes had low priority. A possible cause is a lack of definite authority and personal incentive assigned to the staff responsible for the plant.

9.2 Positive development

During the project, definite improvements of efforts, organisation, and procedures, were obtained. This formed an important part of the technology transfer and the general direct and indirect training, which formed an inherent part of all the work throughout the project.

The high degree of Lithuanian co-production in the project has proved successful, and a considerable amount of knowhow and western working standards and skills have been transferred.

9.3 Conclusion

The general conclusion from the lessons learned in the present project is that the project itself has been a success.

The biogas plant at Vycia is a potential starting point for a large-scale biogas development in Lithuania based upon the high Danish standards of efficiency and reliability. This is substantiated by the intensive training and the high degree of technology transfer and Lithuanian co-production in the project.

The time schedule has been extended several times, and many efforts have been used to solve unexpected problems. Apart from this, everything takes longer time to do in Lithuania compared to Denmark. It will be more realistic to make the time schedule from the most pessimistic feeling and even consider a little extra time. Many problems occurring during the project could not have been predicted, but it is better to consider unexpected events and problems already from the beginning.

The solution of other problems, which mainly occurred because of cultural differences, has been instructive and will be useful for future work and projects.

Annex A , financial statement, Danish funding

Annual State of Accounts from 1995 to 2000

Reporting Period: 1995 Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1. Wages	1.152		75	1.077	1.077	93
	2. Fees, Lithuania	44		0	44	44	100
	3.						
	Sub-total	1.196		75	1.121	1.121	94
Reimbursables							
	1.Travel, board and lodging	178		1	177	177	99
	2.						
	3.						
	Sub-total	178		1	177	177	99
Equipment							
	1. Materials	2.407		0	2.407	2.407	100
	2. Cost of transportation	29		0	29	29	100
	3.						
	Sub-total	2.436		0	2.436	2.436	100
Total		3.810		76	3.734	3.734	98
Contingency							
Grand Total (incl contingency)		3.810		76	3.734	3.734	98

Reporting Period: 1996 , Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1.Wages	1.152	75	509	568	568	49
	2.Fees, Lithuania	44	0	22	22	22	50
	3.						
	Sub-total	1.196	75	531	590	590	49
Reimbursables							
	1.Travel, board and lodging	178	1	61	116	116	65
	2.						
	3.						
	Sub-total	178	1	61	116	116	65
Equipment							
	1.Materials	2.407	0	0	2.407	2.407	100
	2. Cost of transportation	29	0	0	29	29	100
	3.						
	Sub-total	2.436	0	0	2.436	2.436	100
Total		3.810	76	592	3.142	3.142	82
Contingency							
Grand Total (incl. contingency)		3.810	76	592	3.142	3.142	82

Reporting Period: 1997 Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1.Wages	1.152	584	134	434	434	38
	2.Fees, Lithuania	44	22	0	22	22	50
	3.						
	Sub-total	1.196	606	134	456	456	38
Reimbursables							
	1.Travel, board and lodging	178	62	46	70	70	39
	2.						
	3.						
	Sub-total	178	62	46	70	70	39
Equipment							
	1.Materials	2.407	0	701	1.706	1.706	71
	2. Cost of transportation	29	0	4	25	25	86
	3.						
	Sub-total	2.436	0	705	1.731	1.731	71
Total		3.810	668	885	2.257	2.257	59
Contingency							
Grand Total (incl. contingency)		3.810	668	885	2.257	2.257	59

Reporting Period: 1998 Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1.Wages	1.152	718	294	140	140	12
	2.Fees, Lithuania	44	22	20	2	2	5
	3.						
	Sub-total	1.196	740	314	142	142	12
Reimbursables							
	1.Travel, board and lodging	178	108	40	30	30	17
	2.						
	3.						
	Sub-total	178	108	40	30	30	17
Equipment							
	1.Materials	2.407	701	803	903	903	38
	2. Cost of transportation	29	4	13	12	12	41
	3.						
	Sub-total	2.436	705	816	915	915	38
Total		3.810	1.553	1.170	1.087	1.087	29
Contingency							
Grand Total (incl. contingency)		3.810	1.553	1.170	1.087	1.087	29

Reporting Period: 1999 Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1.Wages	1.152	1.012	50	90	90	8
	2.Fees, Lithuania	44	42	6	-4	-4	-9
	3.						
	Sub-total	1.196	1.054	56	86	86	7
Reimbursables							
	1.Travel, board and lodging	178	148	30	0	0	0
	2.						
	3.						
	Sub-total	178	148	30	0	0	0
Equipment							
	1.Materials	2.407	1.504	904	-1	-1	0
	2. Cost of transportation	29	17	11	1	1	3
	3.						
	Sub-total	2.436	1.521	915	0	0	0
Total		3.810	2.723	1.001	86	86	2
Contingency							
Grand Total (incl. contingency)		3.810	2.723	1.001	86	86	2

Reporting Period: 2000 Thousands of Danish Kroner, DKK

Budget Line	Description	A Budgeted Amount (pro.doc.)	B Total in Previous Periods	C Expenditure in Current Period	D Budget for remaining project period	A-(B+C) Balance Remaining	% Remaining
Fees							
	1.Wages	1.152	1.062	90	0	0	0
	2.Fees, Lithuania	44	48	0	-4	-4	-9
	3.						
	Sub-total	1.196	1.110	90	-4	-4	0
Reimbursables							
	1.Travel, board and lodging	178	178	0	0	0	0
	2.						
	3.						
	Sub-total	178	178	0	0	0	0
Equipment							
	1.Materials	2.407	2.408	0	-1	-1	0
	2. Cost of transportation	29	28	1	0	0	0
	3.						
	Sub-total	2.436	2.436	1	-1	-1	0
Total		3.810	3.724	91	-5	-5	0
Contingency							
Grand Total (incl. contingency)		3.810	3.724	91	-5	-5	0

Nordvestjysk
FOLKECENTER
for Vedvarende Energi

Folkecenter for Renewable Energy
Kammersgårdsvej 16, Sdr. Ydby
P.O. Box 208
DK-7760 Hurup Thy, Danmark
T 9795 6600. F 9795 6565
E energy@folkecenter.dk
Homepage: http://www.folkecenter.dk
Giro (c.c.p.) 1199-5934133
SE-nr. 72291212
Den Danske Bank, DK-7760 Hurup Thy
Konto nr. 3415-3415040881
S.W.I.F.T. DABADKKK

Slutregnskab for projektet "Rokel Pig Farm Biogas Demonstration Plant, Kaunas, Lithuania", J.nr. M127-0603.

		Afholdte udg. DKK	Budget DKK
Lønudgifter og honorarer jvf. specifikation		1.152.342,15	1.152.375,00
Øvrige udgifter jvf. bilag fremsendt sammen med periodeopgørelser:			
Materialer:			
1995:	0,00		
1996:	336,64		
1997:	700.731,59		
1998:	803.014,72		
1999:	904.366,28		
2000:	0,00	2.408.449,23	2.406.631,00
Konsulenthonorar for arbejde udført i Litauen:			
1995:	0,00		
1996:	21.600,00		
1997:	0,00		
1998:	19.830,66		
1999:	6.211,71		
2000:	0,00	47.642,37	44.210,00
Rejse- og opholdsudgifter:			
1995:	942,52		
1996:	61.295,69		
1997:	45.872,83		
1998:	40.403,28		
1999:	29.594,48		
2000:	0,00	178.108,80	178.109,00

		Afholdte udg. DKK	Budget DKK
Transportudgifter:			
1995:	0,00		
1996:	0,00		
1997:	4.046,25		
1998:	12.589,00		
1999:	10.500,00		
2000:	1.500,00	28.635,25	28.635,00
Total		**3.815.177,80**	**3.809.960,00**

Modtaget á conto fra Miljøstyrelsen 3.398.535,12 DKK

Resttilgodehavende hos Miljøstyrelsen 411.424,88 DKK

Sdr. Ydby, den 23. marts 2000

Preben Maegaard
Forstander

Ebba Hummelshøj
Bogholder

Nordvestjysk
FOLKECENTER
for Vedvarende Energi

Folkecenter for Renewable Energy
Kammersgårdsvej 16, Sdr. Ydby
P.O. Box 208
DK-7760 Hurup Thy, Danmark
T 9795 6600. F 9795 6565
E energy@folkecenter.dk
Homepage: http://www.folkecenter.dk
Giro (c.c.p.) 1199-5934133
SE-nr. 72291212
Den Danske Bank, DK-7760 Hurup Thy
Konto nr. 3415-3415040881
S.W.I.F.T. DABADKKK

23.03.2000

SPECIFIKATION

over afholdte lønudgifter og honorarer i forbindelse med projektet "Rokel Pig Farm Biogas Demonstration Plant, Kaunas, Lithuania", J.nr. M127-0603.

Alle beløb er i DDK

Ansatte på Folkecenteret:

Projektleder Preben Maegaard:

1995: 28 t. á 215,22 =	6.026,16	
1996: 54 t. á 215,22 =	11.621,88	
1997: 44 t. á 220,85 =	9.717,40	
Ialt 126 t.	27.365,44	
+ DB-tillæg 27.365,44x1,4 =	38.311,61	65.677,05 DKK

Ingeniør Niels Ansø:

1996: 136,5 t. á 149,90 =	20.461,35	
1997: 130 t. á 177,61 =	23.089,30	
1998: 54 t. á 177,61 =	9.590,94	
221 t. á 189,24 =	41.822,04	
286,5 t. á 212,89 =	60.992,98	
1999: 39,5 t. á 215,07 =	8.495,25	
20,5 t. á 216,02 =	4.428,41	
42 t. á 221,49 =	9.302,58	
2000: 144 t. á 221,49 =	31.894,56	
Ialt 1.074 t.	210.077,42	
+ DB-tillæg 210.077,42x1,2 =	252.092,90	462.170,32 DKK

Agronom Lisbeth Christensen:

1996: 253 t. á 148,73 =	37.628,69	
tilbageført		
-10,75 t. á 134,48 =	- 1.445,66	
Ialt 242,25 t.	36.183,03	
+ DB-tillæg 36.183,03x1,2	43.419,63	79.602,66 DKK

Ingeniør Oliver Blome:

1995: 89 t. á 124,91 =	11.116,99	
1996: 62 t. á 124,91 =	7.744,42	
221 t. á 127,16 =	28.102,36	
39,5 t. á 133,75 =	5.283,12	
tilbageført		
-166 t. á 126,64 =	-21.022,24	
Ialt 245,5 t.	31.224,65	
+ DB-tillæg 31.224,65x1,2 =	37.469,58	68.694,23 DKK

Ingeniør Ralph Liedtke:

1997: 14 t. á 133,33 =	1.866,62	
+ DB-tillæg 1.866,62x1,2 =	2.239,94	4.106,56 DKK

Ingeniør Lars Chr. Christensen:

1998: 11 t. á 177,61 =	1.953,71	
90 t. á 180,91 =	16.281,90	
11 t. á 207,40 =	2.281,40	
1999: 3 t. á 212,89 =	638,67	
Ialt 115 t.	21.155,68	
+ DB-tillæg 21.155,68x1,2	25.386,81	46.542,49 DKK

Ansatte i konsulentvirksomheder:

Konsulenthonorar ingeniør Jacob Bugge:

1995: 39 t. á 150,00 =	5.850,00	
1996: 189,5 t. á 180,00 =	34.110,00	
1997: 11,5 t. á 200,00 =	2.300,00	
1998: 3,5 t. á 210,00 =	735,00	
2000: 41,5 t. á 210,00 =	8.715,00	
Ialt 285 t.	51.710,00	
+ DB-tillæg 51.710,-x1,2	62.052,00	113.762,00 DKK

Konsulenthonorar Morsø Landbrugscenter:

1996: 25,72 t. á 388,80		
Ialt 25,72 t. á max. 345,00 =	8.873,40	
+ DB-tillæg 8.873,40x1,2 =	10.648,08	19.521,48 DKK

Enkeltmandsvirksomheder:

Konsulenthonorar ingeniør Jørgen Toft:

1995: 14 t. á 197,87 =	2.770,18	
+ DB-tillæg 2.770,18x1,0	2.770,18	5.540,36 DKK

Konsulenthonorar biokemiker George A. Mathiesen:

1996: 64 t. á 185,00 =	11.840,00	
+ DB-tillæg 11.840,00x1,0	11.840,00	23.680,00 DKK

Konsulenthonorar ingeniør Per Kristensen:

1995: 25,5 t. á 425,00		
1996: 214 t. á 433,77		
Ialt 239,5 t. á max. 345,00 =	82.627,50	
+ DB-tillæg 82.627,50x1,0 =	82.627,50	165,255,00 DKK

Konsulenthonorar Biogaskontor v/E. Köberle:

1996: 7 t. á 355,79		
25 t. á 360,00		
Ialt 32 t. á max. 345,- =	11.040,00	
+ DB-tillæg 11.040,00x1,0 =	11.040,00	22.080,00 DKK

Konsulenthonorar ingeniør S. Laier:

1996: 20 t. á 500,00		
Ialt 20 t. á max. 345,- =	6.900,00	
+ DB-tillæg 6.900,00x1,0 =	6.900,00	13.800,00 DKK

Konsulenthonorar D+O Tegnestuen:

1997: 70 t. á 425,60		
Ialt 70 t. á max. 345,00 =	24.150,00	
+ DB-tillæg 24.150,00x1,0 =	24.150,00	48.300,00 DKK

Konsulenthonorar J. Nielsen VVS:

1997: 1 t. á 205,00 =	205,00	
1998: + DB-tillæg 205,00x1,0	205,00	410,00 DKK

Konsulenthonorar informationsleder Jane Kruse:

1996: 36 t. á 150,00 =	5.400,00	
1997: 8 t. á 150,00 =	1.200,00	
Ialt 44 t.	6.600,00	
+ DB-tillæg 6.600x1,0 =	6.600,00	13.200,00 DKK

Ialt	**1.152.342,15 DKK**

REVISIONSPÅTEGNING

Vi skal hermed erklære os om rigtigheden af det af Nordvestjysk Folkecenter for Vedvarende Energi udarbejdede slutregnskab for projektet "Rokel Pig Farm Biogas Demonstration Plant, Kaunas, Lithuania" J. nr.: M127-0603, udvisende samlede udgifter for i alt kr. 3.815.177,80, dateret den 23. marts 2000.

Det udførte arbejde

Vi har i overensstemmelse med almindeligt anerkendte revisionsprincipper tilrettelagt og udført revisionen med henblik på at opnå en begrundet overbevisning om, at slutregnskabet er uden væsentlige fejl og mangler. Vi har i den forbindelse stikprøvevis kontrolleret antal forbrugte timer til attesterede timesedler, og det bevilligede timeantal, under hensyntagen til Miljøstyrelsens accept om budgetændringer, dateret 14/1-2000 og 16/2-2000. Den anvendte timesats er kontrolleret til den i Miljøstyrelsen anviste opgørelsesmetode, jf. standardvilkårenes punkt 9. Vi har endvidere stikprøvevis kontrolleret de afholdte udgifter til fakturaer og påset, om de er afholdt i perioden 14. november 1995 – 29. februar 2000.

Supplerende oplysninger

Vi kan oplyse, at der ud over de medtagne timer i slutregnskabet, er anvendt yderligere tid på projektet. Disse timer er ikke indregnet i opgørelsen, men udgiften herfor indgår i Folkecenterets årsregnskab som eget bidrag til projektet.

Forbehold

Med hensyn til rejse- og opholdsudgifter, er disse medtaget til kostpriser i henhold til bilag, og ikke efter statens regler om tjenesterejser, som foreskrevet i standardvilkårenes punkt 9.
Vi kan i den forbindelse oplyse, at der i det godkendte budget er beregnet rejseomkostninger efter kostpriser.

Konklusion

Det er vor opfattelse, at slutregnskabet, med undtagelse af det i ovenstående forbehold anførte, er udarbejdet i overensstemmelse med Miljø- og Energiministeriets krav i henhold til aftalen af 14. november 1995, og at det giver et retvisende billede af slutregnskabets resultat.

Hurup, den 28. marts 2000
REVISIONSFIRMAET
BRANDT & SIGSTEN PEDERSEN

Jens Kr. Yde
statsaut. revisor

Annex B, financial statement, Lithuanian funding

Žemės ūkio bendrovė

VYČIA

Farming company

4311, Lietuva, Kauno raj., Rokų apyl., Patamulšėlio km.
Direktorius 74 51 18, 54 52 35, buhalteris 54 51 67, technologas 54 52 37
Atsisk. s-ta Nr. 1405421 Žemės ūkio banko Kauno skyriuje, kodas 260101425

19.99 m. rugsėjo....... mėn. .30.. d. Nr. .206...

Folkecenter for Renewable Energy,
P.O.Box 208, DK-7760 Hurup Thy, Denmark

Att.: Mr. Preben Maegaard

30.09.1999.

Dear Sir,

This to confirm, that installation of the demonstration biogas plant including cogeneration units, at the AC Vyčia is completed.

Expenditures of the AC Vyčia, on demonstration biogas plant construction and materials are as follows:

• Materials	60653,29 Lt
• Construction work	293912,17 Lt
• Piping	14633,- Lt
• Electrical installation	15091,- Lt
• Clay work	19485,13 Lt
• Total:	403781,59 Lt

Kazys Česnavičius
Director
AC Vyčia

Annex C, List of reports and other documents produced by project

Reports

Reducing Waste of Water And Sawdust At Pig Farm, Kaunas, Lithuania
September1996, by Ivar Ravn, Managing Advisor for Farm Construction

Description:
Investigation of the stable and manure handling system at the Vycia Farm concerning possible improvements of manure quality, reduction of water spill etc.

Inspection Report
September 1997, by Niels Ansø

Description:
Inspection report of the delivery of 3 steel digesters.

Foundations for supporting biogas digesters
November 1997, by Niels Ansø

Description:
Investigation of problems by settling foundations supporting the digesters.

Other documents
- Documentation for production of 300m^3 insulated steel digesters.
- Documentation for production of 60m^3 gasholder.
- Documentation of piping for heating-, gas- and manure system.
- Documentation of electrical installation at the biogas plant.
- Documentation on control- and data acquisition system.
- Maintenance instructions for 2 John Deere CHP´s.

Annex D, supporting letters.

- Supporting letter, Lithuanian Energy Agency	**01-02-94**
- Supporting letter, Lithuanian Ministry of Agriculture	**14-01-94**
- Supporting letter, Kaunas District Authorities	**28-12-93**

KE/PM 1/2.94
J.nr. U.34

EA

Republic of Lithuania
Ministry of Energy
ENERGY AGENCY

Gedimino 36,
2600 Vilnius
LITHUANIA

Ph: (3702) 624874,626748
Fax:(3702) 626845
Telex:261240 TLG LT

To: Preben Maegaard
Director
Danish Folkecenter

No 118/Fok

31 January 1994

Dear Sir,

I am thankful for your intentions expressed in a written message of 13 January 1994 as well as your efforts to promote assistance to Lithuania. Biogas power plants' construction is a new way for energy resources utilization in Lithuania which allows to use efficiently imported fuel and improve ecological situation. Such type of power plants comply with the National Energy Conservation Programme's, approved by the Government of Lithuania, basic considerations.

Taking into account above mentioned, Lithuanian Ministry of Energy approves of your idea regarding projects of biogas power plants to be built in Rokai and Raudonė.

Yours sincerely,

D.Mikalajūnas
Managing Director

KE 14/1

W.3.4

LIETUVOS RESPUBLIKOS
ŽEMĖS ŪKIO MINISTERIJA

Gedimino pr. 19, 2025 Vilnius
Tel.: 622654
Fax: 224440
Telex: 261181 AGRO

1994 01 13 Nr. 1420 - 10

Mr. Kristian Eriksen
Folkecenter for renewable energy
Kammergaardsvej 16, Sdr. Ydby
DK -7760 Hurup Thy, Denmark
Fax 45 - 97956565

Dear Mr. Eriksen,

According to the information that we have received Folkecenter for Renewable Energy, Denmark together with its office in Kaunas and with Lithuanian Energy Institute are going to present an application for the Danish Government for the grants for two pilot biogas plants each of them using different technologies.

These projects are fully consistent with the agricultural reform policy implemented by Lithuanian Government. Such pilot plant would be able to demonstrate a way how Lithuania could better provide itself with energy produced from local renewable resources - organic waste and manure and at the same time considerably reduce pollution of air, surface and underground water by intensive animal husbandry farms. At the same time, anaerobic manure treatment can produce high quality, environment-friendly fertilizers which are better absorbed by plants what brings down the total demand for fertilizers.Cheap energy production could also reduce production costs. At the same time the biogas plant could bring contribution to economic development, employment and welfare of rural people.

Because these two pilot plants will serve for demonstration purposes the projects puts emphasis on training and technology transfer. We consider these projects as one step forward in the cooperation between Lithuania and Denmark in the fields of agriculture, energetics and environment protection. In the next future we will be able to say what contribution to the projects can be made by Lithuanian party including local labor and construction works..

Lithuanian Ministry of Agriculture gives its complete approval and support to the projects Rokel and Kingfarm to be implemented in Rokai and Raudone, Kaunas district, respectively.

Sincerely yours,

R.Karazija
Minister

LIETUVOS RESPUBLIKA

KAUNO RAJONO VALDYBA

3042 Kaunas, Savanorių pr. 371, tel. 714515, tel./fax. 713797, atsiskaitomoji sąskaita Nr. 010130208 Lietuvos Valstybinio Komercinio Banko Kauno skyriuje

1996 12 28 Nr. 731

Danish Agency of Environment
Denmark

The implementation of biogas technologies is expected in Lithuania to be a significant tool in reduction of environmental problems and imports of oil, gas or coal and nuclear power. In the energy sector biogas could enable the farmers to provide himself with heat and electricity and to supply the excess to national grid. It would highly increase the income of a farm.

The authorities of our district supported from the very begining the efforts of Lithuanian Energy Institute and Folkecenter, Denmark, to find the best option for a demonstrational biogas plant in the district. We have recomended "Vyčia" pig farm in Rokai (name of project Rokel) as a reliable basis for a demonstrational project.

Nevertheles highly needed is also a second project for another demonstrational biogas plant. The cow farm in Raudonė (name of project - Kingfarm), Kaunas district, 40 km from the city, is a perspective farm. It is privatized to a joint-stock company and could be a solid partner in the realization of the project.

Numerous efforts of the farmers could not reduce its adverse impact on the surroundings: the air carries bad smell, the ground water is polluted and a real hazard for the drinking water exists. We all expect the biogas plants could improve essentialy the situation in environment and supply of power. The digestered manure and organic waste supplyed from Kaunas slaughterhouse factory, will be used as fertilizer and will increase agricultural production.

We would be glad if the two biogas plants would be installed in our district as they would be one of the first operating plant in the East Baltic region.

We are thankful to Danish Government for the grant and shall do our best in realization of the project.

Chief Administrator of Kaunas district P. Vengeliauskas

Annex E , information activities

Below are listed some of the information activities related to the project. The list is not complete, but it shows a good representation of the activities.

List of seminars and presentations

The project has been presented on several seminars as well as some seminars have taken place directly on the Vycia farm.

Date	Title	Place	Speaker / author
Jan 1996	Introduction to biogas technology. Meeting with involved parties incl. the county mayor	Kaunas, Lithuania	Preben Maegaard Ernst Breum
6-7/2, 1996	Technical and economical analysis of a prospective biogas plant in Lithuania	Kaunas Technological University, Lithuania	J. Savickas, Klementavicius Lithuanian Energy Institute
12/3. 1997	Centralised biogas plants in Western countries and possibilities of their application in Lithuania	Kaunas Technological University, Lithuania	J. Savickas, J. Ziugzda Lithuanian Energy Institute
10-11/2, 1998	The perspective of biogas plant construction and efficiency estimation in Lithuania	Kaunas Technological University, Lithuania	J. Savickas Lithuanian Energy Institute
9-10/11 1998	Energy from Waste and Biomass	Tallinn, Estonia	Niels Ansø Folkecenter
16-18/11 1998	IV Conference on Industrial Thermoenergitic	Santa Clara, Cuba	Lars Chr. Christensen Folkecenter
7-9/1 1999	Jahrungs Versammlung, Fachverband Biogas	Weckelweiler, Germany	Preben Maegaard Folkecenter
4-5/2 1999	Analysis of "Vycia" demonstration biogas plant operation	Kaunas Technological University, Lithuania	J. Savickas Lithuanian Energy Institute
5/3 1999	Local Fuel Resources	AC Vycia Farm Lithuania	Mindaugas Stalnionis Kaunas Energy Office
1/5 1999	Local Fuel Resources	Vilnius, Lithuania	Mindaugas Stalnionis Kaunas Energy Office
14/5 1999	Sustainable and Renewable Energy	Kaunas Technological University	Mindaugas Stalnionis Kaunas Energy Office
/1 2000	Eurosolar Conference, Der Landwirt als Energiewirt	Berlin, Germany	Preben Maegaard Folkecenter
1-2/2, 2000	Possibilities on improving biogas production efficiency out of organic waste	Kaunas Technological University, Lithuania	J. Savickas Lithuanian Energy Institute

List of articles

Lithuanian

Stasys Zienius, "Pirna energija, paskui trašo", Meisteris (Technical magazine), 6th issue 1998

Diana Medeliene, "Biogas Power Plant-Yet Another Demonstration Project"
Energy News, Quarterly News Magazine from the Energy Agency of Lithuania., Nr.4(14)-1998

Navickas K., Anciunas A., Janusauskas R. "Content and Biogas Yield Evaluation of Pig Manure" // Research papers of LIA AgEng & LU of Ag, 1999, Vol 31, No 1, P. 47-58. (Lithuanian)

Navickas K. "Potential of Biogas Production from Agricultural Wastes"
// Engineering. Research papers of Lithuanian University of Agriculture, 1999, No 4, P. 92-97. (Lithuanian)

Navickas K. "Pilot biogas plant in agricultural enterprise “Vycia”"
//Agricultural Engineering and Energetics, 1999, No 1 P. 66-70.
(Journal of the Faculty of Agricultural Engineering of LUA).

Danish

Dansk BioEnergi, 42nd issue, P. Maegaard, December 1998, P.8
Vedvarende Energi & Miljø, P. Maegaard & N. Ansø, December 1999
Smedetidende, December 1999

International

Ansø N., "Demonstration Biogas Plant, Kaunas, Lithuania"
Sustainable Energy News, No.24, Feb. 1998

Kraftjournalen, 6th issue, 1998, P.22, Nordic countries
SERO Journalen, Sweden, 1st issue, 1999
Biogas-Journal, Fachverband Biogas e.V., Germany, 1st/2nd issue, June1999

Other publications

Brochure:

J.Savickas, S. Vrubliauskas."Possibilities of biogas production and implementation in Lithuania"
V.://Lituanian Energy Agency, 1997.-38 p.

Research reports for Lithuanian Energy Agency:

"The analysis of construction, starting-up and initial operation of "Vycia" demonstration biogas plant", Scientific Report / Lithuanian Energy Institute.-1998.-37 p.

"Evaluation of the pilot biogas plant operation efficiency at the AC "Vycia""
Scientific Report/Lithuanian Energy Institute.-1999.-46 p.

Leaflet:

Rokai Pig Farm Demonstration Biogas Plant:
General information about the project. 4 pages, English Language.

Roku demonstracine bioduju jegaine:
General information about the project. 4 pages, Lithuanian Language.

Postcards:

6000 postcards with the motif of the biogas installation and some brief information. The postcards have been spread many different places e.g. at the AGRO BALTIC exhibition in Vilnius, 1999.

Internet:

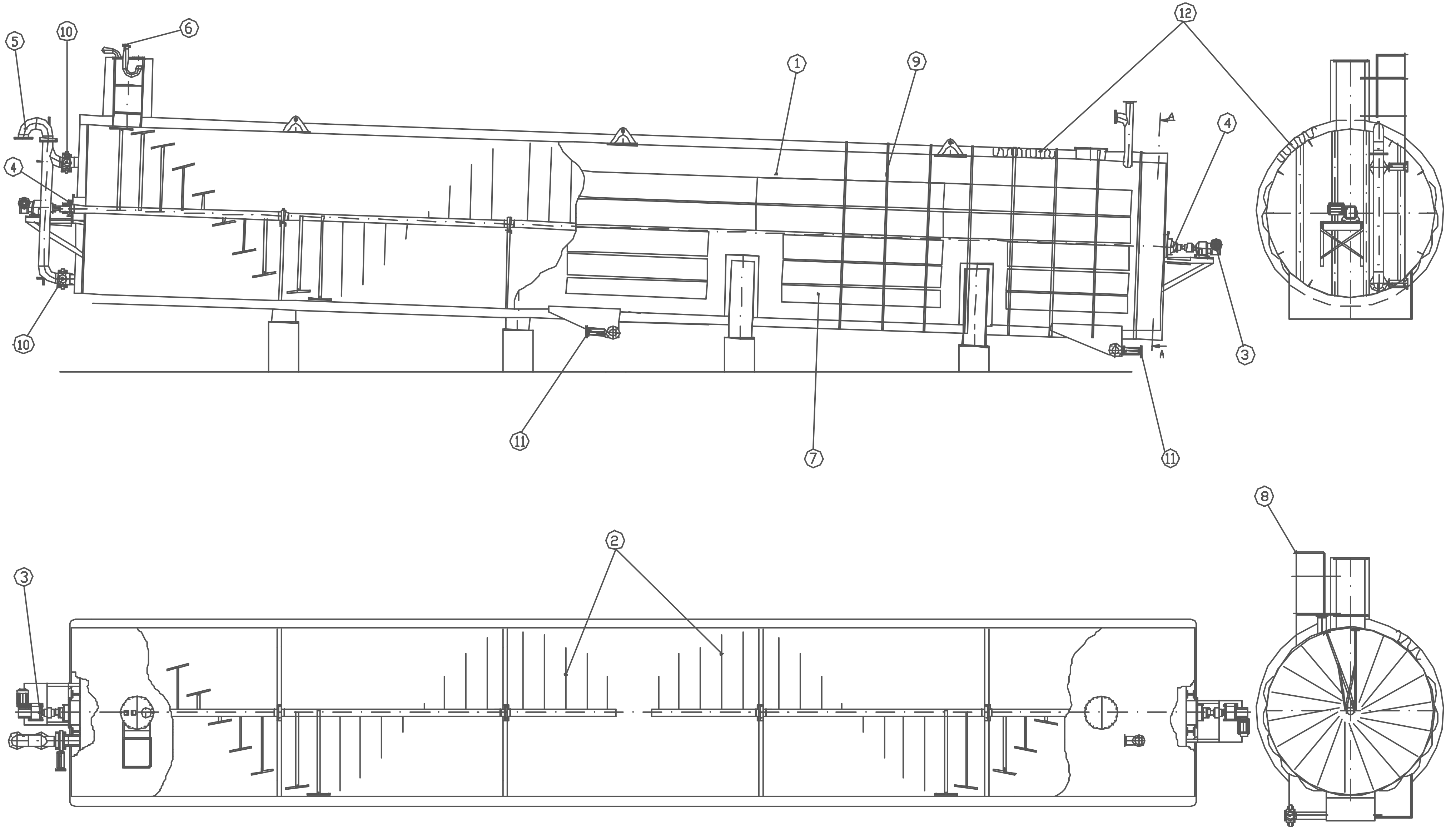
Information in English language has been published on the Folkecenter homepage under www.folkecenter.dk/rokai/rokai.html . The page has had some 1700 visitors from November 1998 to March 2000.

Annex F , travels to Lithuania

Date	Purpose	Name
Jan 1996	General visit, information. Taking samples of the manure for analysis.	Preben Maegaard Ernst Breum
Apr 1996	General visit, preparations.	Ernst Breum
Aug/Sept 1996	General visit. Examination of the stable system with regard to reduction of water spill and dilution of the manure.	Jane Kruse Lisbet Christensen Ivar Ravn
Dec 1996	Planning and preparations for the implementation. Agreement with the Vycia farm was prepared. Investigation of which technical equipment was available in Lithuania was carried out.	Lisbet Christensen Niels Ansø
Feb 1997	Planning and preparations for the implementation. The design and situation of the technical building were agreed. ICC was visited at their factory in Mazeikiai.	Preben Maegaard Jane Kruse Niels Ansø Kenneth Olsen
May 1997	General inspection and dialog on all construction activities.	Niels Ansø
Jul 1997	General inspection and dialog on all construction activities.	Preben Maegaard Jane Kruse Niels Ansø
Oct 1997	General inspection and dialog on all construction activities. Investigation of problem with settling of digester foundation.	Niels Ansø Farhad Sabzevari
Dec 1997	General inspection and dialog on all construction activities.	Niels Ansø Ralph Liedtke
Mar 1998	Solution of problem with insulation. Supervisor came to instruct ICC workers in the insulation work from beginning to completion of one digester. General inspection and dialog on all construction activities.	Niels Ansø Thorkild Christiansen
Apr/May 1998	General inspection and dialog on all construction activities.	Niels Ansø
Sept 1998	Inspection and approval of delivery of the 3 digesters and gasholder	Preben Maegaard Niels Ansø
Sept 1998	Installation of computer control system	Niels Ansø Lars Chr. Christensen Adrian Stukenborg
Nov 1998	Consideration on available time for starting up process before inauguration	Niels Ansø
Nov 1998	Inauguration. 3 staff members and 2 board members of the Folkecenter participated.	Preben Maegaard Jane Kruse Jens Jensen Ole Albertsen Niels Ansø
Dec 1998	Follow up.	Niels Ansø
Feb 1999	Follow up.	Niels Ansø
March 1999	Follow up. Visit with supervisor from Danish biogas plant.	Niels Ansø Karl Erik Jensen
May 1999	Follow up	Niels Ansø
Sept 1999	Follow up. Visit in order to accelerate the installation of CHP units.	Niels Ansø
Nov 1999	Starting up of CHP units	Niels Ansø Johann Hochreiter

Annex G, additional technical documentation

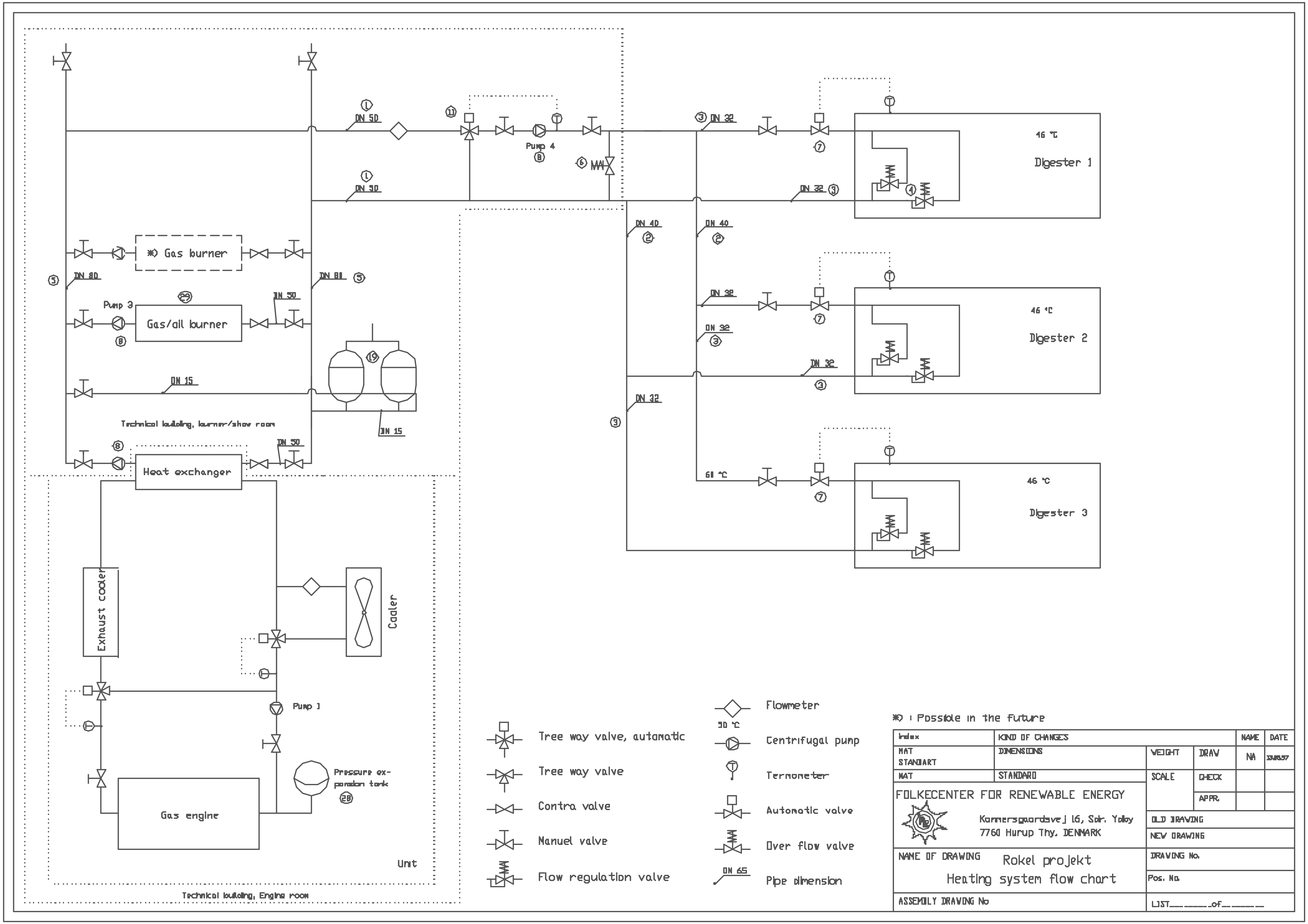
- Drawing of 300 m^3 horizontal digester for Lithuania: 1 page
- Diagram for heating system: 1 page
- Diagram for gas system: 1 page
- Diagram for manure system: 1 page
- Diagram for data acquisition and control system: 2 pages



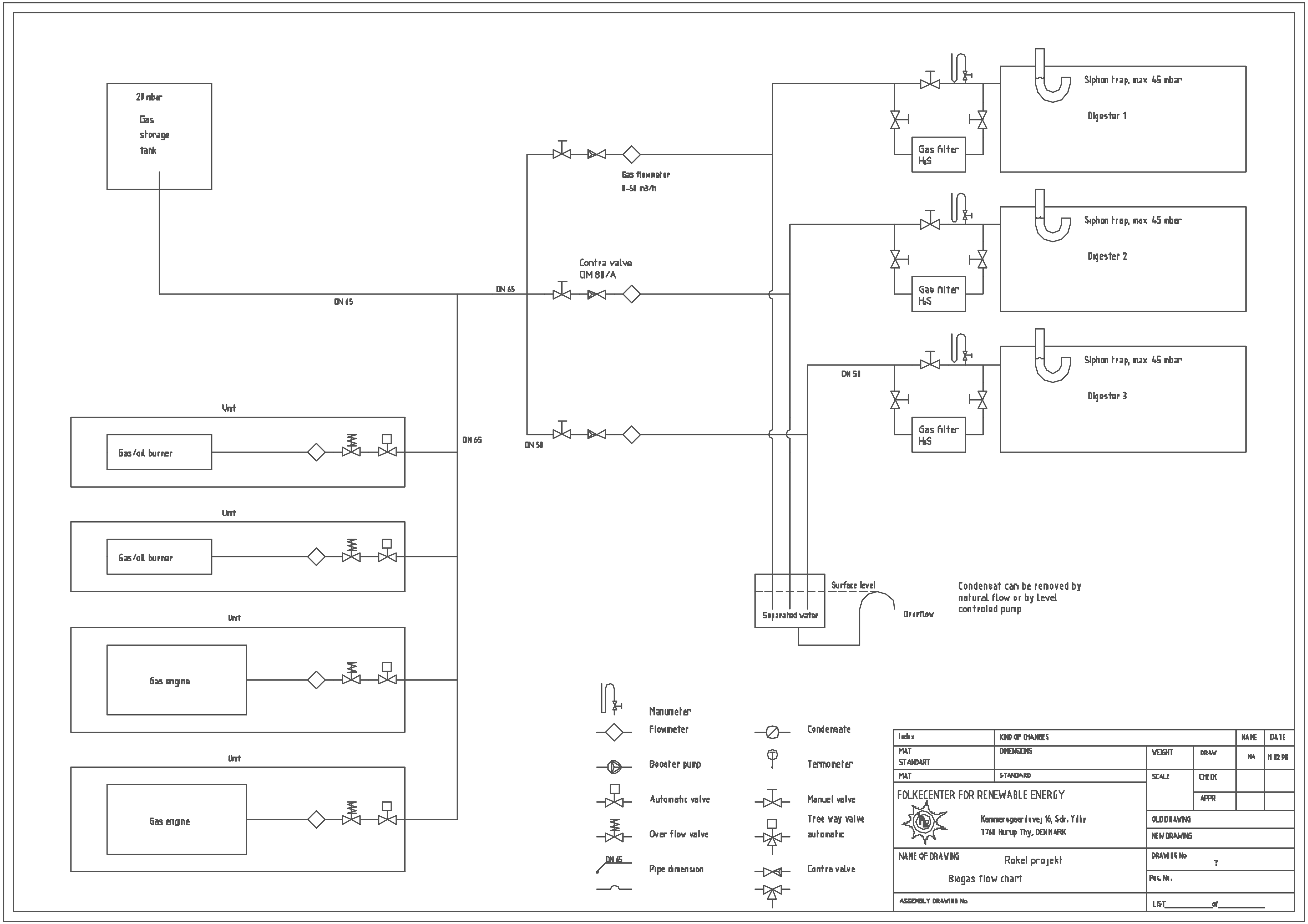
1 Tank
2 Agitator
3 Consol for agitator gear
4 Bearings and sealings
5 Manure outlet
6 Gas system (with siphon trap)
7 Heat exchanger
8 Platform
9 Frame for insulation
10 Knife gate valve
11 Knife gate valve
12 Insulation material

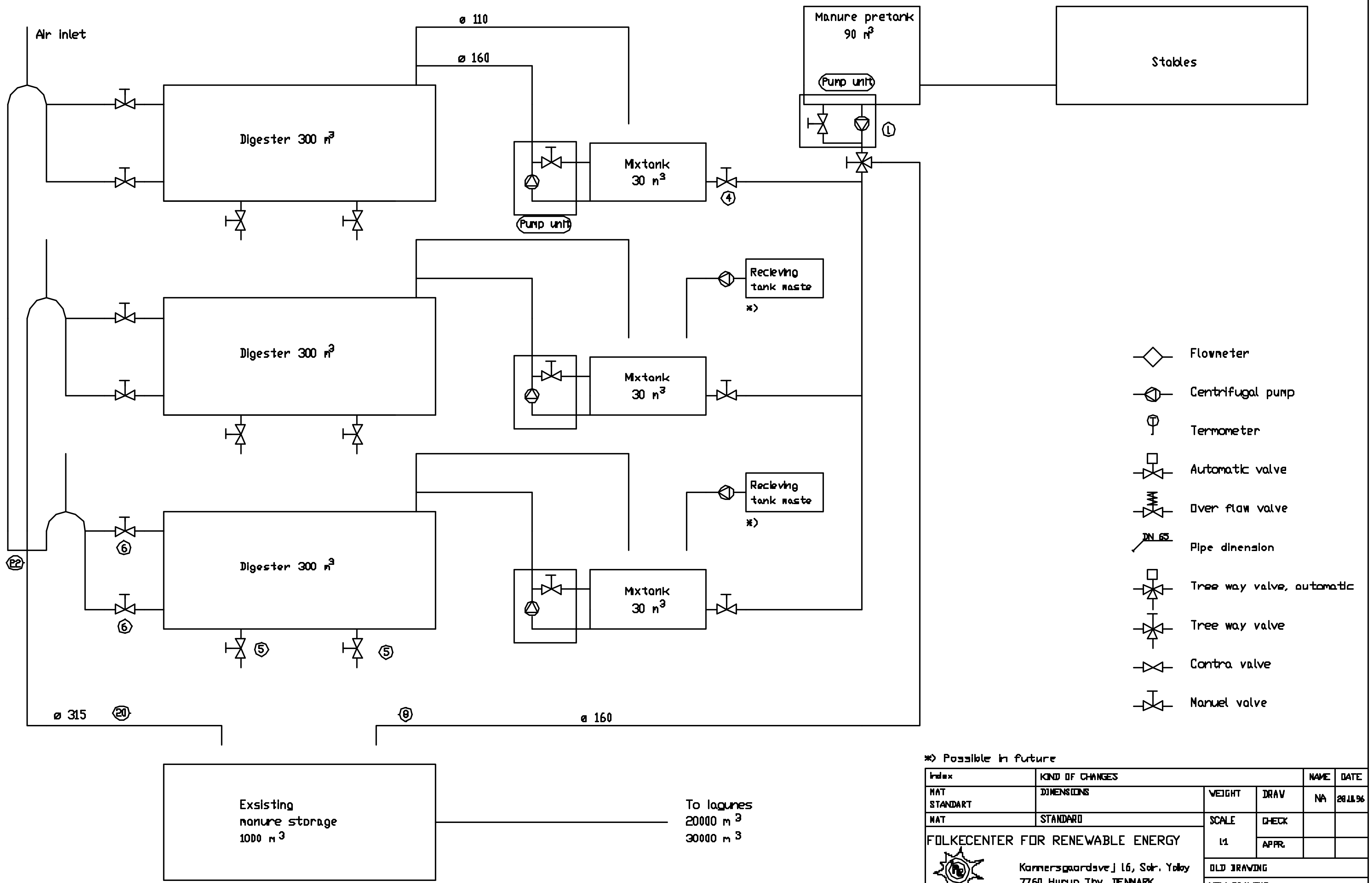
see parts list 3-0

KIND OF CHANGES				NAME	DATE
DIMENSIONS		WEIGHT	DRAW		
STANDARD		SCALE 1:40	CHECK		
FOLKECENTER FOR RENEWABLE ENERGY Kammersgaardsvej 16, Sdr. Ydby 7760 Hurup Thy. DENMARK			APPR.		
		OLD DRAWING			
		NEW DRAWING			
NAME OF DRAWING ROKEL BIOGAS PLANT 300m³		DRAWING No 3-0			
		Pos. No.			
ASSEMBLY DRAWING No		LIST ___ OF ___			

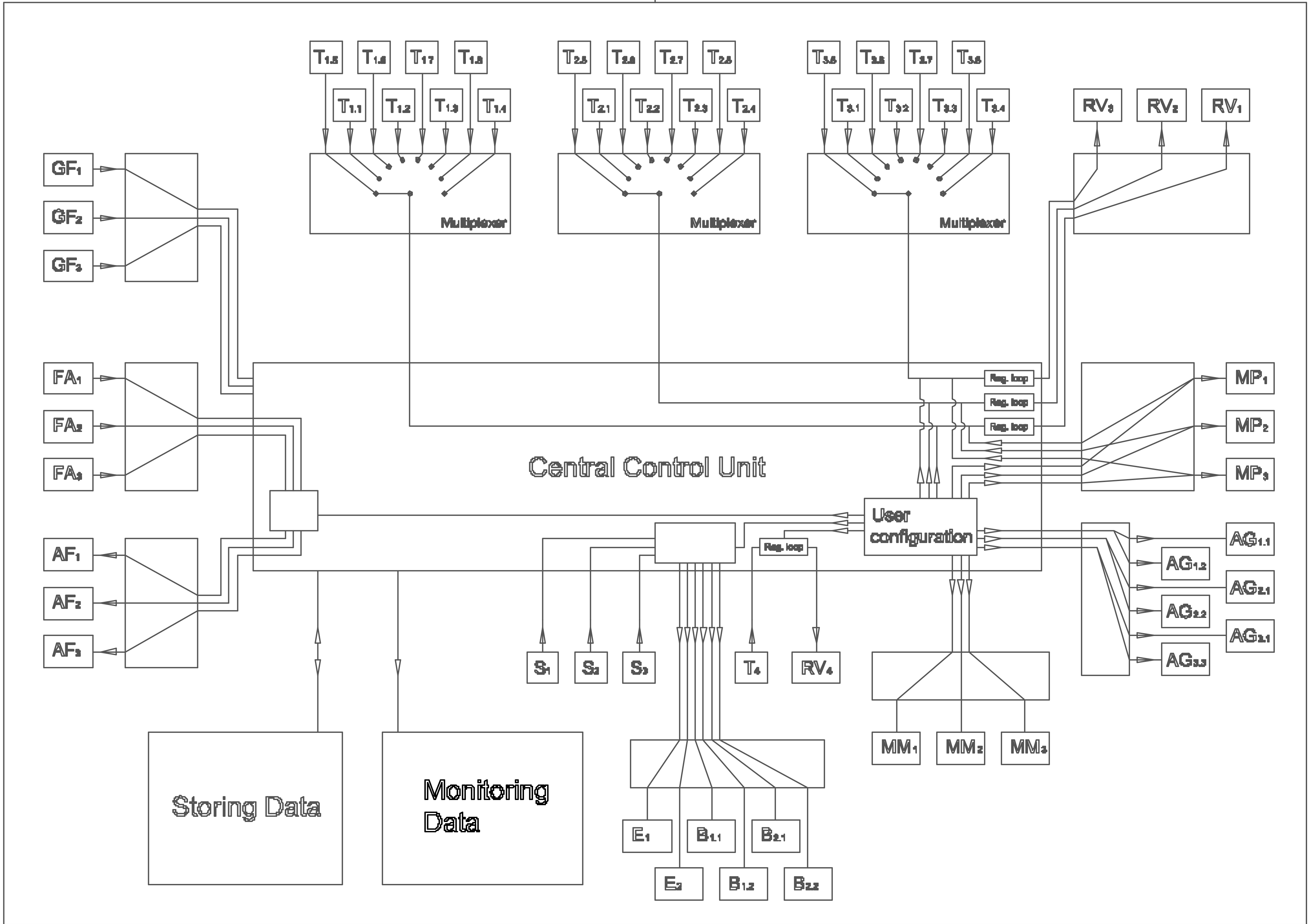


DN 50
DN 50
Pump 4
DN 32
DN 32
46 °C
Digester 1
DN 40
DN 40
*) Gas burner
DN 80
DN 80
Pump 3
Gas/oil burner
DN 50
DN 32
DN 32
46 °C
Digester 2
DN 32
DN 15
DN 32
DN 15
Technical building, burner/show room
DN 50
Heat exchanger
61 °C
46 °C
Digester 3
Exhaust cooler
Cooler
Pump 1
Pressure expansion tank
Gas engine
Unit
Technical building, Engine room
Tree way valve, automatic
Tree way valve
Contra valve
Manuel valve
Flow regulation valve
Flowmeter
50 °C
Centrifugal pump
Termometer
Automatic valve
Over flow valve
DN 65
Pipe dimension
*) : Possible in the future
Index
KIND OF CHANGES
NAME
DATE
MAT STANDART
DIMENSIONS
WEIGHT
DRAW
NA
MAT
STANDARD
SCALE
CHECK
APPR.
FOLKECENTER FOR RENEWABLE ENERGY
Kammersgaardsvej 16, Sdr. Ydby
7760 Hurup Thy. DENMARK
OLD DRAWING
NEW DRAWING
NAME OF DRAWING
Rokel projekt
Heating system flow chart
DRAWING No.
Pos. No.
ASSEMBLY DRAWING No
LIST_______of_______

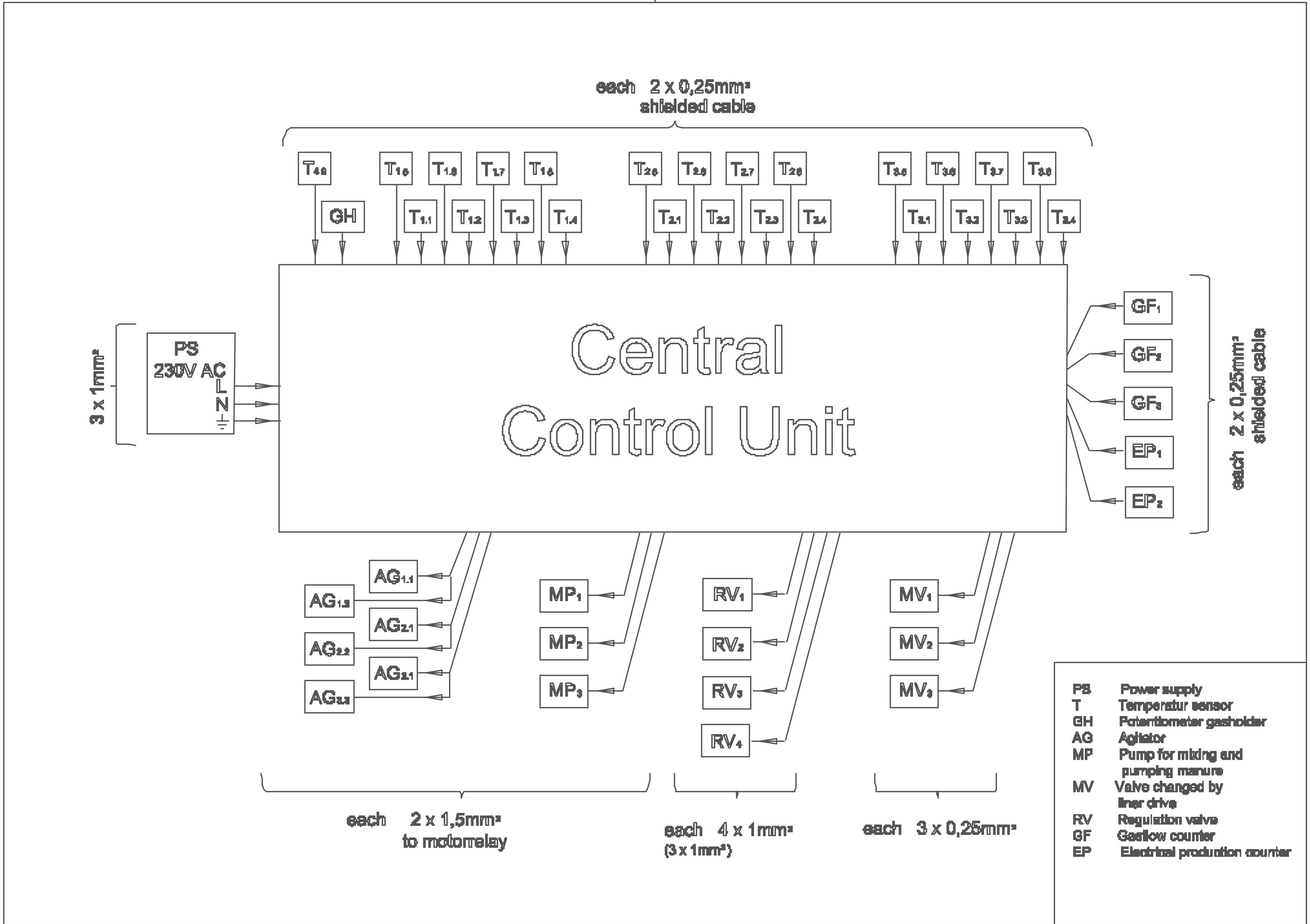

20 mbar
Gas
storage
tank
DN 65
DN 65
DN 65
DN 50
DN 50
Gas flowmeter
0-50 m3/h
Contra valve
OM 80/A
Siphon trap, max 45 mbar
Digester 1
Gas filter
H₂S
Siphon trap, max 45 mbar
Digester 2
Gas filter
H₂S
Siphon trap, max 45 mbar
Digester 3
Gas filter
H₂S
Unit
Gas/oil burner
Unit
Gas/oil burner
Unit
Gas engine
Unit
Gas engine
Surface level
Separated water
Overflow
Condensat can be removed by
natural flow or by level
controled pump
Manumeter
Flowmeter
Booster pump
Automatic valve
Over flow valve
DN 65
Pipe dimension
Condensate
Termometer
Manuel valve
Tree way valve
automatic
Contra valve
Index
KIND OF CHANGES
NAME
DATE
MAT
STANDART
DIMENSIONS
WEIGHT
DRAW
NA
11 02 98
MAT
STANDARD
SCALE
CHECK
APPR
FOLKECENTER FOR RENEWABLE ENERGY
Kammersgaardsvej 16, Sdr. Ydby
7760 Hurup Thy, DENMARK
OLD DRAWING
NEW DRAWING
NAME OF DRAWING
Rokel projekt
Biogas flow chart
DRAWING No
7
Pos. No.
ASSEMBLY DRAWING No
LIST
of



Index	KIND OF CHANGES			NAME	DATE
MAT STANDART	DIMENSIONS	WEIGHT	DRAV	NA	28.11.96
MAT	STANDARD	SCALE 1:1	CHECK		
FOLKECENTER FOR RENEWABLE ENERGY			APPR.		
Kammersgaardsvej 16, Sdr. Ydby 7760 Hurup Thy. DENMARK		OLD DRAWING			
		NEW DRAWING			
NAME OF DRAWING	Rokel projekt Manure systen flow chart	DRAWING No. 7			
		Pos. No.			
ASSEMBLY DRAWING No		LIST______of______			



T1.5
T1.6
T1.7
T1.8
T1.1
T1.2
T1.3
T1.4
T2.5
T2.6
T2.7
T2.8
T2.1
T2.2
T2.3
T2.4
T3.5
T3.6
T3.7
T3.8
T3.1
T3.2
T3.3
T3.4
RV3
RV2
RV1
Multiplexer
Multiplexer
Multiplexer
GF1
GF2
GF3
FA1
FA2
FA3
AF1
AF2
AF3
Central Control Unit
Reg. loop
Reg. loop
Reg. loop
MP1
MP2
MP3
User configuration
Reg. loop
AG1.1
AG1.2
AG2.1
AG2.2
AG3.1
AG3.3
S1
S2
S3
T4
RV4
MM1
MM2
MM3
Storing Data
Monitoring Data
E1
B1.1
B2.1
E2
B1.2
B2.2


each 2 x 0,25mm²
shielded cable
T4.9
GH
T1.5
T1.6
T1.7
T1.8
T1.1
T1.2
T1.3
T1.4
T2.5
T2.6
T2.7
T2.8
T2.1
T2.2
T2.3
T2.4
T3.5
T3.6
T3.7
T3.8
T3.1
T3.2
T3.3
T3.4
3 x 1mm²
PS
230V AC
L
N
Central
Control Unit
GF1
GF2
GF3
EP1
EP2
each 2 x 0,25mm²
shielded cable
AG1.1
AG1.2
AG2.1
AG2.2
AG2.1
AG3.3
MP1
MP2
MP3
RV1
RV2
RV3
RV4
MV1
MV2
MV3
each 2 x 1,5mm²
to motorrelay
each 4 x 1mm²
(3 x 1mm²)
each 3 x 0,25mm²
PS Power supply
T Temperatur sensor
GH Potentiometer gasholder
AG Agitator
MP Pump for mixing and pumping manure
MV Valve changed by liner drive
RV Regulation valve
GF Gasflow counter
EP Electrical production counter

Annex H, Production data

Year	Week No.	**Total**				**VS% in mixertank**			**Average/day**		
		Manure m^3	waste m^3	Manure m^3	gas m^3	1	2	3	Manure m^3	waste m^3	gas m^3
1999	15	142	2,0	140,0	3419				20	0,3	488
	16	401	2,0	399,0	7695				57	0,3	1099
	17	434	6,6	427,4	9035				62	0,9	1291
	18	294	9,5	284,5	7971				42	1,4	1139
	19	294	0,7	293,3	6439				42	0,1	920
	20	294	0,0	294,0	5647				42	0,0	807
	21	270	5,0	265,0	5909				39	0,7	844
	22	249	0,7	248,3	5515				36	0,1	788
	23	253	1,2	251,8	4958				36	0,2	708
	24	294	0,2	293,8	5760				42	0,0	823
	25	301	0,8	300,2	5363				43	0,1	766
	26	294	5,4	288,6	6014				42	0,8	859
	27	294	2,6	291,4	5238				42	0,4	748
	28	189	14,6	174,4	6891				27	2,1	984
	29	130	12,4	117,6	7884				19	1,8	1126
	30	253	32,3	220,7	7269				36	4,6	1038
	31	287	22,5	264,5	8096				41	3,2	1157
	32	294	30,4	263,6	7097				42	4,3	1014
	33	240	21,7	218,3	7835				34	3,1	1119
	34	168	29,3	138,7	6674				24	4,2	953
	35	231	21,7	209,3	5070				33	3,1	724
	36	196	20,7	175,3	3432				28	3,0	490
	37	294	31,4	262,6	2944				42	4,5	421
	38	31	14,6	16,4	252				4	2,1	36
	39	85	20,8	64,2	2443				12	3,0	349
	40	249	23,9	225,1	12031	7,51	5,67	2,80	36	3,4	1719
	41	332	25,3	306,7	14700				47	3,6	2100
	42	217	12,5	204,5	15582				31	1,8	2226
	43	210	23,8	186,2	12720	4,92	5,78	5,11	30	3,4	1817
	44	270	22,5	247,5	10746				39	3,2	1535
	45	210	38,6	171,4	9224	8,73	13,37	3,88	30	5,5	1318
	46	294	51,6	242,4	10580	5,76	5,56	6,17	42	7,4	1511
	47	294	14,7	279,3	10563				42	2,1	1509
	48	300	0,0	300,0	9590				43	0,0	1370
	49	294	21,0	273,0	4353	4,31	4,19	4,72	42	3,0	622
	50	297	20,2	276,8	10105	5,56	2,23	2,69	42	2,9	1444
	51	294	7,0	287,0	9326				42	1,0	1332
	52	392	9,0	383,0	7776				56	1,3	1111
2000	1	342	8,0	334,0	7505				49	1,1	1072
	2	303	11,3	291,7	6141	2,30	2,95	4,34	43	1,6	877
	3	304	9,5	294,5	5926				43	1,4	847
	4	297	10,7	286,3	4600	3,17	3,20	3,31	42	1,5	657
Average		**265**	**14,7**	**250**	**7293**		**4,93**		**37,8**	**2,1**	**1042**

Annex I, electricity prices for the Vycia farm

In the following 2 tables are given the electricity prices stated in the agreement between the Vycia farm and the local Utility Company. The prices for buying and selling electricity are identical.

Lithuanian currency

Electricity prices for Vycia farm valid from January 1st 2000 Sell price = buy price							
Winter prices : 1/9 - 31/4				Summer prices : 1/5 - 31/8			
Time		Hours	Price LTct/kWh	Time		Hours	Price LTct/kWh
23:00	07:00	8	12,3	23:00	07:00	8	12,3
07:00	08:00	1	15,7	07:00	08:00	1	15,7
08:00	10:00	2	25,3	08:00	10:00	2	25,3
10:00	18:00	8	15,7	10:00	23:00	13	15,7
18:00	20:00	2	25,3				
20:00	23:00	3	15,7				
Time weighted average			16,17	Time weighted average			15,37

US currency

Electricity prices for Vycia farm valid from January 1st 2000 Sell price = buy price							
Winter prices : 1/9 - 31/4				Summer prices : 1/5 - 31/8			
Time		Hours	Price USct/kWh	Time		Hours	Price USct/kWh
23:00	07:00	8	3,08	23:00	07:00	8	3,08
07:00	08:00	1	3,93	07:00	08:00	1	3,93
08:00	10:00	2	6,33	08:00	10:00	2	6,33
10:00	18:00	8	3,93	10:00	23:00	13	3,93
18:00	20:00	2	6,33				
20:00	23:00	3	3,93				
Time weighted average			4,04	Time weighted average			3,84

Annex J, Programme for biogas study and working trip to Denmark

Programme for biogas study and working trip to Denmark. March 1999.

Participants:

Liudas Staras	Vice director **Vycia Farming Company**. Director of economy
Algis Lukosevicius	Manager biogas plant at **Vycia Farming Company**
Dr. Juozas Savickas	Senior research associate, **Lithuanian Energy Institute**
Kestutis Navickas	Ass. Prof., Dr. of tech. Science, **Lithuanian Univercity of Agriculture**

Wednesday 17/3 , 1999

11:30 Arrival to Billund. Folkecenter car will drive to Folkecenter
14:00 Arrival to Folkecenter. Lunch
15:00 Tour on Folkecenter
17:00 Meeting with Preben Maegaard, Niels Ansø, Jane Kruse,
Liudas Staras, Algis Lukosevicius, Juozas Savickas and Kestutis Navickas.
Lithuanian parts presents
- Results for the operation of the biogas plant up to now
- Availability of organic waste.
- Agreements made for delivery of waste
- installations on the farm, connection of heating system, manure system etc.
- Etc.

19:00 Dinner
20:00 Continuation of discussion

Thursday 18/3 1999

7:30	Departure excursion
9:45	Visit to Vaarst-Fjellerad biogas plant. This plant have been operated since ~2 years. It is a medium-sized centralised biogas plant. The plant receives waste from municipality of Aalborg.
12:45	Lunch
14:00	Arrival to Vester Hjermitslev Biogas Plant. The supervisor Karl Erik Jensen has been leader of this medium-sized centralised plant since 1984.
19:00	Arrival Folkecenter. Dinner.
20:00	Discussion of the excursion.

Friday *19/3 1999*

9:00	Continuation discussions and meetings for the future operation of Vycia biogas plant. Preben Maegaard, Niels Ansø. Liudas Staras, Algis Lukosevicius, Juozas Savickas and Kestutis Navickas.
12:00	Lunch
13:30	Visit to biogas plant at Jens Kirk, Skinnerup. Visit to pig stables to see Danish Standard pig stables.
15:30	Shopping in Thisted.
18:00	Return to Folkecenter.
19:00	Dinner.

Saturday 20/3 1999

9:15	Departure excursion
10:00	Visit to Ejnar Kirk farm Biogas Plant, Hillerslev. New technologies: Dual fuel motor, 2 digesters in serial configuration, receiving of slaughterhouse waste, gas cleaning with active coal filter.
11:30	Visit to biogas plant at Jens Kirk, Skinnerup. See manure handling equipment.
12:00	Visit to Folkecenters 525 kW wind turbine in Hanstholm
13:00	Lunch in Hanstholm
14:30	Visit to Vorupør landing place. Old tradition fishing with boats landing directly on the beach.
16:00	Visit to biogas plant at Holger Krappe, Grønnegård, Boddum.
17:00	Visit to Ydby Hede. Graves from Vikings.

Sunday 21/3 1999

8:00	Departure Folkecenter.
9:45	Visit to Esbjerg fishing harbour.
10:15	Visit to windturbines at Tjærreborg Enge. (2 MW, 2 x 1.5 MW, 1 MW)
11:30	Visit to Jens Jensen, Rejsby. Head of board of Folkecenter.
13:30	Visit to church in Rejsby.
14:00	Visit to decentralised co-generation plant in Rejsby.
14:45	Visit to "Kammerslusen", Ribe (sluice).
15:15	Visit to Ole Albertsen, member of board of Folkecenter. Renewable community with 14 families. (windturbine, solar heating)
16:00	Shopping/walk in Ribe historical city.
18:00	Arrival Billund Airport.
19:00	Liudas Staras return to Lithuania.

Monday 22/3 to Thursday 25/3 1999

8:00	Algis Lukosevicius participate in daily work at Vester Hjermitslev biogas plant.

Monday 22/3 1999

9:00	Preparing short and long terms programme for future operation of biogas plant at Vycia Farming Company. (Daily routines, waste management, laboratory, etc.) Juozas Savickas, Kestutis Navickas, Niels Ansø.
12:00	Lunch
19:00	Dinner

Tuesday 23/3 1999

9:30 Visit to Jens Kirk pig farm. Studying manure removal system in stables.
Juozas Savickas, Kestutis Navickas.
13:00 Lunch
13:30 Continuation of programme from Monday.

Wednesday 24/3 1999

8:30 Departure Folkecenter.
9:30 Visit to Vestas Windfarm at Vejlerne. 35 x 600kW.
11:00 Visit to Vegger medium size centralised biogas plant.
13:00 Visit to DLG raps oil factory, Agersted. The Factory is pressing 290 t raps seed/day.
14:00 Lunch
15:00 Walk in the village of Asaa. Old fishermen town at east coast of Jutland.
19:00 Return to Folkecenter, dinner.

Thursday 25/3 1999

8:30 Continuation of programme from Monday.
12:00 Lunch.
19:00 Dinner.
20:30 Meeting Juozas Savickas, Kestutis Navickas, Algis Lukosevicius and Niels Ansø.
Discussion of result of work during visit.

Friday 26/3 1999

8:30 Continuation of programme from Monday.
12:00 Lunch.
13:00 Meeting, finishing discussion.
Juozas Savickas, Kestutis Navickas, Algis Lukosevicius and Niels Ansø
15:00 Departure to Billund airport.
19:00 Flight Billund - Kaunas, return to Lithuania.
Juozas Savickas, Kestutis Navickas, Algis Lukosevicius.