Project no: **COOP-CT-2006-032609**

Project acronym: **BIOWELL**

Project title: Increased Renewable Energy Recovery from Biomass by highly Efficient Disruption process

CO-OPERATIVE RESEARCH PROJECT

Final Activity Report

Period covered: From 2007-11-15 to 2009-5-14

Submission date: October 2009

Start date of the project: November 15, 2006

Duration: 30 months

PROJECT COORDINATOR: Clausthaler Umwelttechnik-Institut GmbH (CUTEC)

Project acronym: BIOWELL

Project N°: COOP-CT-2006-032609

Periodic activity report

Project Coordinator: Clausthaler Umwelttechnik-Institut GmbH (CUTEC)

Project Coordinator: Dr. rer. nat. Ottmar Schläfer

Date *Signature*

Task: 5.1: Ongoing Reporting, Periodic activity

Participants: CUTEC, CVUT, DCU

Duration: 30 months

Starting point: November 2006

Current Status: Completed

Contents

Publishable Executive Summary

The BIOWELL project has been completed, having achieved all the milestones and deliverables specified in the work packages which met the pre-planned milestones and end user requirements. The completion of the five (5) work packages consisting of system specification, laboratory tests, process integration, demonstration test as well as exploitation and dissemination plans confirm the completion this project which span through a period of 30 months.

The project direction and subsequent modifications was based on the end-user requirements, which can be traced back to all the requirements and specifications given by UBF as the BIOWELL end-user, which was identified and documented and it includes all the requirements needed to achieve the project goals. The testing, evaluating, providing functionality, applying and completing the automation of the Biowell plant as required, was done during the last 6 months period of extension which was very important in order to complete WP3 and WP4 as well.

The results arrived at would be of immense benefit to other industrial areas like food, alcohol, pharmacology, agriculture and other relevant industries having put into consideration the objectives of the European Community (EC) towards the end user and SME's. The information generated from the BIOWELL project is also intended to be used in the academic area and as a basis for future research. The disseminating strategy will take the form of printed materials in journals, publications, bulletins and through the soft media which include the internet (BIOWELL website, press conferences, media interview etc). The details of the exploitation and disseminating plan would guide the eventual launching of BIOWELL to Europe and beyond. Within past 30 months, all miles stones in the work packages have been reached and patent rights are clearly outlined with plans for exploiting the results obtained (as stated in WP5). Having tested and launch the prototype equipment, we have to once again note that the pre-treatment bio-reactor is capable of increasing the efficiency of differently selected bio-processes significantly. It is also noted that, industrial areas where micro-organisms are used as submers bio-conversion and degradation processes will be good potential zones for the applications of this plant. Comparisons and projections into the future of how this project would benefit beyond the present scope to other areas have been carefully studied.

Introduction

This final report is developed based on the progress reports submitted earlier as well as the submitted periodic activity reports during the 30 months period of the project, including the 6 months extension period. The report is divided into sections to allow for easy review, while taking conclusive summary for all previous achievements till the end of the project. Therefore, the plan for the completion of the project using WP1 to WP5 will be highlighted in the table below with particular reference to the technical sub sections:

WP	TASKS	OBJECTIVES
1	**System Specification**	Identification of the end-user requirements, the legislative requirements and the technical requirements and economical specification
	1.1	Identification of end-user requirements
	1.2	Identification legislative and standards requirements
	1.3	Identification of technical requirements
	1.4	Identification of economical specifications
2	**Laboratory Tests**	Test definition and build up, tests implementation and integration, Lab development of control system and test evaluation
	2.1	Definition of lab-test procedures
	2.2	Build up of lab-test system
	2.3	Integration and lab tests
	2.4	Development data evaluation
	2.5	Test data evaluation
3	**Process Integration**	Design and optimization of prototype, first tests on prototype and system integration
	3.1	Manufacturing of BIOWELL prototype
	3.2	Lab tests with the prototype
	3.3	System integration at end-user's side

4	**Demonstration phase**	Execution of performance test on field, performance matrix of prototype, test data evaluation, commercial exploitation
	4.1	Definition of demonstration test procedure
	4.2	Execution of the demonstration tests
	4.3	Test data evaluation
	4.4	Planning of commercial units
5.	**Exploitation, Dissemination**	Coordination and reporting, final financial and administrative reports, establishment of public website, dissemination plan and exploitation plan
	5.1	Coordinating and reporting (ongoing for dissemination)
	5.2	Final reports (as presented in this 30 month report)
	5.3	Public website
	5.4	Dissemination achievements
	5.5	Exploitations achievements

The classification and evaluation of test results was continuous done by the three (3) research partners (CVUT; DVU and CUTEC) during the last phase of this project. The manufacturing activities have been carried out using experimental data from the laboratory tests and the experiences of CUTEC in the area of sludge treatment from wastewater treatments plants (WWTPs). With these inputs, the prototype was designed by BHR with the input from all RTD partners. The construction partner GHM was furnished with all needed drawings and calculations by BHR.

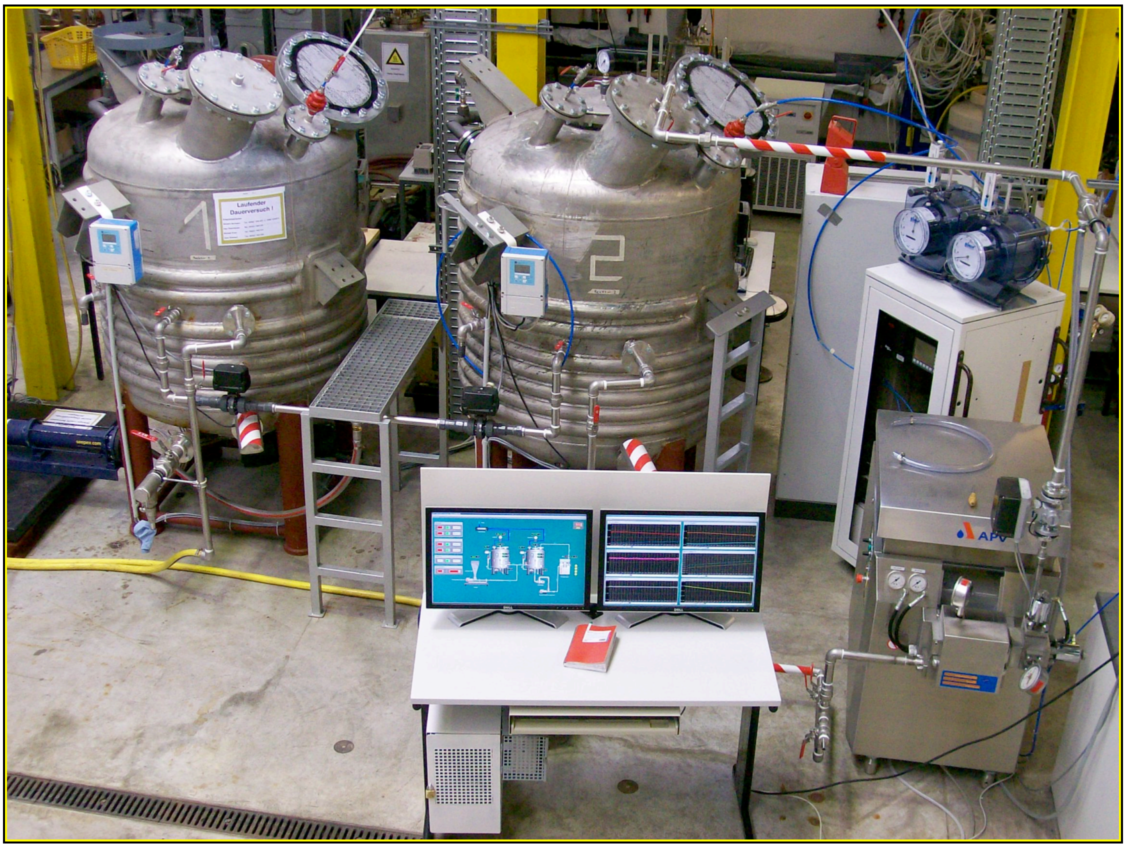

Figure 1: Homogenizer Pre-treatment Process Section in the Biogas Plant

The high-pressure biomass pre-treatment system was adapted to industrial biogas-plants with the process control system from C-L. A functionality test was conducted and all non-conformities of BIOWELL were identified so that the execution of performance on the field could be defined. With the assistance of the partners DCU, DSM, GHM and BHR the whole prototype was set up at CUTEC's site and the first tests with the prototype were completed on schedule.

Section One: Project Objectives and Major Achievements

The fundamental goal of the project was achieved as a result of the ability of the biogas plant developed of being able to increase the output of biogas through anaerobic digestion of homogenised biomass in an optimized anaerobic digestion system. The improvement of biological digestion was achieved by the introduction of a biomass pre-treatment process, based on the disruption of organic materials and cell structures of the biomass to increase the concentration of solved nutrients as feed for the micro-organisms involved in the anaerobic digestion process using both ultrasound and homogenizer pre-treatment process.

The last phase of the project was completed by integrating the prototype as a singular plant with all the functional systems and thereafter, performing the demonstration tests. As this could not been achieved in the regular project runtime an extension of 6 months was agreed with European Commission. This extension period according to the revised **proposal No. 0323609** was to include the execution of demonstration test and establish a process integration methodology that will illustrate how the entire concept and design will applied at the end user side. In this regard, the prototype was evaluated with respect to its assembly and workability from testing performance.

The assembly and prototype evaluation stage was performed having in mind the fundamental goal of the project which is the application of a pre-treatment technology and the main objective was to determine and develop the most efficient pre-treatment process for maximal energy recovery from biomass. This assembly therefore used cumulative effort from all previous stages, deliverables and work packages with inputs from all partners, thereby making the evaluation and demonstration process a possibility with excellent results.

A programme for testing the performance of the BIOWELL system was developed by CUTEC and DCU which led to the final assembly of the plant. Several tests were carried out using this program in identifying all non-conformities of BIOWELL system before trials are carried out. The testing procedure was in line with set standards and we are happy to say that the quality assurance also proved positive results. The diagram in figure 1 below shows a sample prototype plant configuration as used in BIOWELL.

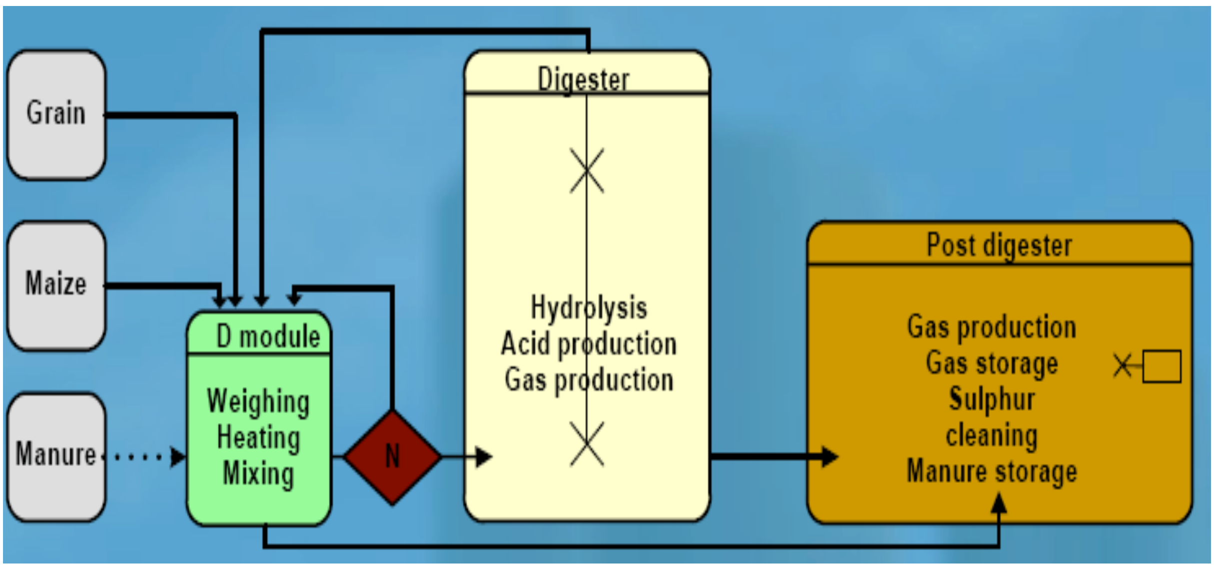

Figure 2: Plant configuration and general assembly concept

This final report is a conclusion of the 12th, 18th, 24th to the 30th month with the small-scale demonstration and the industrial scale demonstration phase, which lead us to the completion of WP1, WP2, WP3, WP4 and WP5. The small-scale demonstration section was completed which help in the development of the industrial scale that was optimized and demonstrated to validate the results acquired from previous pilot scale test. The process control system of C-L was integrated in the prototype to help in the functionality test carried out before the test trials. The objectives of this task were to program the execution of performance tests on field in such a way that it will be possible to obtain a reliable evaluation of the prototype's performance under real conditions. CUTEC and DCU developed a program for testing the performance of the BIOWELL system.

The achieved objectives were as follows:

- The automation of the prototype with the integration of the process control system of C- L to control and regulate every single part of the prototype automatically.
- Integration of BIOWELL prototype at end user's side with the installation of software and hardware components.
- Developing a program for testing the performance of BIOWELL system. Therefore, DCU and CUTEC will program the execution of performance tests on field.

The Integration of the prototype into industrial biomass digestion process has been carried out to integrate the prototype biomass disruption system into industrial anaerobic biomass digestion process. This led to an innovative design of a prototype biomass disruption and pre-treatment system and a Construction of a flexible pre-treatment system which is assembled for industrial biogas-plants for energy purposes.

The main objectives and the achievements recorded in this project can be summarized as given in section 1.1 and section 1.2 for quick overview.

1.1 Main Project Objectives

- Identification of the end-user requirements, the legislative requirements and the technical requirements and economical specification.
- Test definition and build up, tests implementation and integration, Lab development of control system and test evaluation.
- Design and optimization of prototype, first tests on prototype and system integration.

- Execution of performance test on field, performance matrix of prototype, test data evaluation, commercial exploitation.
- Coordination and reporting, final financial and administrative reports, establishment of public website, dissemination plan and exploitation plan.

1.2 Main Project Achievements

The achievements recorded during the thirty (30) months period of the project includes:

- Definition of Demonstration of test procedure
- Execution of demonstration test
- Test data evaluation, quality assurance and end user compatibility
- Completion of the Biowell prototype
- Performance of demonstration and evaluation test on the prototype
- Integration of exploitation and dissemination plan with a commercial out look
- Demonstration test procedure, evaluation of the entire BIOWELL process
- Website update

1.3 Extension Period

An extension period of 6 months was agreed upon with European Commission according to the revised **proposal No. 0323609** and it includes the execution of demonstration test and establishment of a process integration methodology that illustrated how the entire concept and design will applied at the end user side. As a result, the prototype was evaluated with respect to its assembly and workability from testing performance.

The main activity for the last phase of the project (six months extension period) is the demonstration test of WP4.

Section Two: Highlights during the 30 Months Project Period.

The main activities for the entire life cycle of this project (thirty (30) months project period) are the system specification WP1, laboratory tests WP2, process integration WP3, demonstration test WP4, as well as exploitation and dissemination plans WP5. So therefore, a brief summary of all the activities of WP1 to WP5 would be highlighted to show how the early activities led to the success of the later and eventual the success of the project.

2.1 Work package 1: System specification

2.1.1 Objectives and starting point of work at the beginning of the period

The aim of this work package is to define the requirements of the BIOWELL system in accordance with the end user's needs and the legislative requirements, to define the functionality of BIOWELL; to develop the characteristics of components, materials- and of the prototype's layout with respect to the technologies to be investigated (Homogenizer and ultrasound)

2.1.2 Progress towards objectives

Task 1.1: Identification of end-user requirements

The partners specified the performance requested from the BIOWELL system. The partners contributed to this task by gathering of data, establishing the main practical functionality and expected effect of the homogenizer and ultrasound systems.

For the field tests, which will be carried out at a UBF plant in Germany, the BIOWELL will be directly integrated in the plant. A detailed description of UBF plants layout is compiled in deliverable D01.

Task 1.2: Identification of legislative and standardization requirements

An overview over the current legislative situation in Europe regarding renewable energy in general and from biomass in particular have been highlighted in D01.

Relevant national, European and international biogas and biogas plants standards and the aspect e safety regulations have been considered in D01 as well. This document will be updated during the project.

Task 1.3: Identification of technical requirements

To develop a strategy for further proceeding intensive literature search was done. An amount of citations and publications was analyzed and interpreted. Under consideration of extracted Information, focus of research activities was defined in accordance with the total aim of pre-treatment technology (ultrasound or homogenizer) prototype development. Within this process, dimensions, type, variety and proceedings of experiments was determined. The laboratory experiments were invested in CUTEC, who has proved over the past their human, technical and material capabilities to successfully conduct such experiments. The tests which should be carried out will be presented in Deliverable D05 of the Work Package 2.

Task 1.4: Economical specification of BIOWELL

At this point, the focus has been to come up with a simple procedure to quickly specify the economics of the final BIOWELL technology as more data from lab tests and full-scale experiments become available. An EXCEL spreadsheet was prepared, which computes the Net Present Value (NPV), the Internal Rate of Return (IRR), the Return on Investment (ROI) and the Pay out Time (POT). On this basis, the profitability of BIOWELL will be determined. Based on the information, a Cost and Benefit analysis will be done and integrated in the dissemination stage to support demonstration of the advantages of the BIOWELL technology and to facilitate its commercialization.

2.1.3 Deviations from the work program and corrective actions

While the project was started in late autumn (November 15th) 2006, it was not possible to bring together the whole consortium and to get started in 2006. With the kick-off meeting in February 2007, the project started with a delay of two months. As a corrective action, UBF employed an additional technician and BHR included two more students in the project work. With these efforts, the delay could be reduced to the half and the work package 1 was successfully completed end of moth 4 instead of month 3 as calculated in the work program.

2.1.4 List of Deliverables

No.	Title	Scheduled	Status	Date
D01	End-user requirements document	Month 2	Completed	June 2007
D02	Legislative requirement document	Month 2	Completed	July 2007
D03	Technical specification	Month 3	Completed	August 2007
D04	Economical specification	Month 2	Completed	July 2007

2.1.5 List of Milestones

No.	Title	Scheduled	Status	Date
M01	Initial specification completed	Month 3	Reached	August 2007

2.2 Work package 2: Laboratory tests

2.2.1 Objectives and starting point of work at the beginning of the period

The objective of this work package is to conduct intensive laboratory tests in order to identify the most appropriate technology for BIOWELL. This involves first the definition by CUTEC of the lab tests procedures for the homogenizer and ultrasound systems respectively. This will be followed by the build up of the lab tests system, the integration and the proper lab tests, the development of a control system and finally, the evaluation of the data derived from tests. This work package forms the object of the next step towards progress of the project and will be followed by the Work packages 3 and 4.

2.2.2 Progress towards objectives

Task 2.1: Definition of lab-test procedures

Two types of tests were carried out at the different RTD partners. In accordance with the project requirements, CVUT proposed and developed a strategy of lab test with ultrasound together with CUTEC and DCU worked out the programme for homogenizer tests. The partners defined their tests and created their lab test protocols.

CUTEC

Under consideration of extracted information, focus of research activities is defined. Within this process, dimension, type, variety and proceedings of experiments is determined. Demands in laboratory equipment and material are defined.

Result of literature search and evaluation showed, that research efforts should be focused on different aspects. On the one hand, activation of pure enzyme solutions in vitro seemed to be promising on the other hand experiments should be transferred to in vivo systems. As tests with enzymes are extremely expensive and complex, relevant experiments should be done in small volumes in micro scale. To assure reliability and accuracy of results, experiments should be done in multiplates. Thus, an integration of a high-throughput system with possibility of automation is helpful. Therefore, special equipment for liquid handling, measuring and data evaluation were necessary.

DCU

In the course of consideration and test planning, decision was made to carry out homogenizer experiments in micro scale. Measurements of enzymatic activity bases on kinetic measurements with special micro scale photometers. For handling of samples in micro scale and to assure a high throughput to provide reliable and significant results, a device for liquid handling is necessary. Thus the implementation of an integrated platform for handling and measuring samples in micro plates as well as treatment of samples with homogenizer in a high-throughput scale is one focus of this task.

Further on, results need to be transferred and verified with in vivo systems. For evaluation of in vivo systems, complex systems of analyses are necessary. Complex analyses are not possible in a small-scale system. Thus a scale of 500 ml was supposed to work with in vivo systems in batch experiments. Additionally, a system for ultrasonic treatment of samples needed to be established.

CVUT

An aerobic ultrasound model system was selected that is very reproducible and the fermentation takes only some hours. On this system all process parameters would be investigated to find the best parameters and to develop scale-up rules.

The preliminary laboratory experiments were terminated by specification of model test procedures. Special bacterial cultures were selected that grow under aerobic conditions were selected. CVUT was able to execute their experiments in Microbiological Institute of Czech Academy of Sciences, where fermenters of 5, 35 and 300 l were only adapted and equipped with ultrasonic generators. The instrumentation is described in Deliverable D07. Some experiments will be also executed in accordance with procedures for silage fermentation, which is a typical anaerobic biomass process.

Task 2.2: Build up of a lab-test system

CUTEC

Technical requirements, laboratory equipment and material have to be chosen according to defined strategy. Within this process, previous available resources have to be considered. Equipment is implemented in laboratory process to build up a functional platform for laboratory test system. Therefore, special equipment for liquid handling, measuring and data evaluation is necessary. Thus the implementation of an integrated platform for handling and measuring samples in laboratory scale as well as treatment of samples with ultrasound in a high-throughput scale is one focus of this task.

DCU

Another focus was the selection of suitable system for tests in 500 ml and 5 l scale. Existing resources in material and devices have to be integrated. Technical requirements, laboratory equipment and material were chosen according to defined strategy, developed methods and previous available resources. A great challenge of this task is the establishing of an integrated handling system for high- throughput scale as well as development of appropriate methods Selection and implementation of necessary equipment and demands is completed.

A complete platform for automated liquid handling and measuring of samples in small scale is implemented in laboratory procedure. Equipment for 500 ml and 5 l experiments are integrated. Arrangements for appropriate homogenizer treatments of samples are considered and totally integrated. Necessary material is selected and delivered. Finally, complete requirements are fulfilled and equipment is ready-to-operate.

CVUT

The advantage of existing fermenters installed in the Microbiological Institute of Czech Academy of Sciences have been taken into consideration and been adapted for experiments with ultrasonic irradiation. Ultrasonic generators were manufactured and supplied to CVUT in July 2007. In order not to loose time CVUT decided to make some experiments with the commercially available horn-probe generator. CVUT has already built and tested equipments with fermenters 5 and 35 L. For the fermenter 300 L everything was prepared for the tests.

Task 2.3: Integration and lab tests

Considering test plans and strategy developed in task 2.1 and 2.2 appropriate bioprocesses and –systems are selected and methods are developed. To evaluate effect of ultrasound on different systems, several analytical parameters are determined measured. Test systems concerning special parameters are developed, tested and integrated on laboratory platform. Data are collected, analysed and will be evaluated soon for presentation.

As a suitable system for determination of enzymatic activity under impact of ultrasound, two different enzymatic systems are chosen. First enzyme is of interest because of its part in anaerobic fermentation. Second enzyme is part of a system, being well analyzed in process of lactose hydrolysis, an important fermentation process in the silage-making of biomass. The process of lactose fermentation and the impact of ultrasound on this procedure is already well investigated and results are published.

To guarantee possibility to transfer results gained in enzymatic activity experiments, micro-organisms containing these special systems are selected. Thus these micro-organisms were used over all working platforms, from micro scale to 5 L scale. Working platforms are described and elucidated in the task reports. Cells were treated differently with ultrasound and homogenizer to verify the best effect which was evaluated while measuring several parameters like optical density, biogas production, gas concentration (Methan and Carbindioxide), consumption of substrate, product concentration and cell viability.

For scale up of experimental results, a 5 l system with two reactors in parallel was installed.

Thus, comparison of ultrasonic treated and untreated samples in large scale was possible with this unique system. Analytic methods were nearly the same as in 500 ml scale with ultrasound and homogenizer to gain comparable results.

Task 2.4: Development of a control system

Based on experiences gained in the executed experiments and theoretical considerations the strategy of process control was formulated from C-L. Attention was devoted to the by-pass loop that has a character of supplementary equipment for any existing bioreactor.

Bioreactors have their own process control usually supplied along with the bioreactor that is specific for each technology. For the experiments the already existing control system has been used. The data transmission system and the control system for the prototype is in progress.

Task 2.5: Test data evaluation

The task of this work-package is evaluation of experimental data. The aim of experiments has been to prove the effect of ultrasonic irradiation on micro organisms growth rate under different operating conditions in comparison with the activation effect and the economical benefit of the homogenizer treatment.

The reported data have been obtained with experiments that differ by the pre-treatment procedure (ultrasound / homogenizer) and the investigated process (bye-pass / in-line), size and generator type. The used experimental procedure is described in the Deliverable D05 and test arrangement in the Deliverable D07. Identical trials with and without ultrasonic irradiation are compared. Different content of dry matter and biomass concentration are compared. Ultrasonic irradiation is specified by time exposition and generator power input and total energy supplied into broth. For the exponential growth period data have been represented by an exponential function and from it the growth rates corresponding to single trials have been determined. Same procedure of data evaluation was made to have these two investigated pre-treatments methods (ultrasound and homogenization) as the most promising activation processes for biogas plants comparable.

2.2.3 Deviations from the work program and corrective actions

The testing procedure has been changed during the project in order to save time because of the already occurred delay from the late project start and work package 1. The main change was to make available additional resources (personnel and material) at the research partner's side (CUTEC, CVUT and DCU). This lead to high efficient laboratory test procedures and only a minimum of new construction of test-equipment was needed from GHM. GHM therefore, has only a few MM worked in WP 1 and just concentrated on WP3 to fasten the prototype construction procedure.

At CVUT the up-scaling tests have not been finished at the end of the first project year. In order to get appropriate data for scale-up and prototype lay-out in work package 3, also DCU is still carrying out some more laboratory tests with homogenizer and biomass.

Some delay occurred in the achievement of some deliverables due to a delay in obtaining the relevant information. No additional corrective action in work package 2 is necessary to reach the set goals.

The complete evaluation of the laboratory scale data (Task 2.5, which is still in work) will be completed in the early beginning of 2009 and the already started work package 3 thereafter, will be continued rapidly.

2.2.4 List of Milestones

No.	Title	Scheduled	Status	Date
M02	Process and engineering data for building up the pilot plant	Month 9	Reached	December 2007

2.2.5 List of Deliverables

No.	Title	Scheduled	Status	Date
D05	Laboratory test procedure specification and commissioning list	Month 4	Completed	August 2007
D06	Laboratory test arrangement	Month 5	Completed	October 2007
D07	Lab-test data and evaluation	Month 9	In process	Expected in February 2008
D08	Control and data transmission system	Month 8	Completed	November 2007

2.3 Work package 3: Process Integration

2.3.1 Objectives and starting point of work at the beginning of the period

The objective of this work package was to automate the prototype and integrate the missing parts for the functionality tests. This work package forms the objective and continuation of work package 4.This task deals with the construction of the technical pre-treatment system, which is required to integrate the optimal disruption system (ultrasound or high-pressure homogenizer). This system integrates the new developed and pre-tested system into a technical biogas plant. According to the specifications drawn in WP2, the prototype was constructed and is now ready for the eventual test and commissioning. The prototype was equipped with several elements like computer controlled and automation elements, automation valves and control elements. C-L was responsible for the settings of these elements and will be able to control and regulate the prototype via remote monitoring from distance. After the integration and calibration, it was possible to run the prototype automatically. With this last step, the manufacturing and commissioning of the prototype was completed.

2.3.2 Progress towards objectives

Task 3.1: Manufacturing/Commissioning of BIOWELL prototype

BHR calculated on the basis of laboratory data from Dublin (DCU) and Clausthal-Zellerfeld (CUTEC) the exactly scale of the prototype. The proportions of the single components from the laboratory tests were shifted to the prototype. In connection with the construction of the prototype the partner GHM started to furnish a component list, in which all single and necessary module for the construction of the prototype were listed (D09). Via cost estimate from the manufacturer and actual market rate for commodities and metals, BHR and DMS could draw a calculation of cost and a calculation of profitability, so that the costs were well calculated.

A summary of design, calculation of cost, calculation of profitability and the component list were sent to all partners for appreciation and for one's own utilization. On basis of this information it was possible to order the components the partners needed and to make arrangements with the other partners. Most relevant information were forwarded to GHM, who was assigned with the assembling of the prototype. Thereupon, a meeting was arranged in Prage, which should answer the purpose for futurities.

In this meeting it had been decided that the assembling should take place at CUTEC's side and which production steps are necessary up to the complementation of the prototype. Deciding for the choice of the location of the prototype were criteria like adequate space, mould gating to power and supply lines and dry surrounding area as well as competent qualified personnel for supervision and servicing. Besides the central location of the CUTEC inside of Germany guarantee an ideal delivery and therewith, save resources and time. In addition the process control system (C-L) and the homogenizer (DMS) are also developed in Germany. Another decision criterion for the selection of the CUTEC as location for the complementation was the Institution-specific analytic department and the nearness to other institutes.

During development of the process control system by C-L using information from BHR it was emphasized that the system is mobile and easy in assembling. For this reason it was handed to CUTEC personally without any problems. In the following weeks the homogenizer from DMS and a bigger part of the needed materials for the assembling of the prototype arrived at CUTEC. The technical equipment for assembling was brought by GHM and allocated by CUTEC. After every completed processing step all partners were informed about the actual intermediate result and the next actions via webpage. While assembling the prototype C-L deducted settings several times to guarantee a failure-free assembling.
The workings for the most part were completed but several small elements like sensors, computer controlled and automated processes, automated valves and control elements are actually not integrated. As soon as these parts are available the prototype tests are able to run automatically. Nevertheless several system checks could be carried out (Task 3.2).

Task 3.2: Lab tests with the prototype

After the commissioning and manufacturing of the prototype parts the whole prototype was assembled at CUTEC's side and the first tests with the prototype were carried out with the assistance of the partners DCU, DMS, BHR and GHM. This were done to prove the system under real industrial conditions with the observation and support of the construction partner GHM and therewith, assure a failure free test run at the end users-side later. After assembling the hardware of the prototype some function tests were carried out:

- Hydrostatic test: A great water amount was filled via the mixing vessel into the system to check the tubes and also the connections for tightness. For this reason it could excluded that in later passes no sludge is able to leak out of the system.

- Flow path test: The flow path test was carried out with water too. It was tested if the system is able to work with great amounts of liquid media without losing liquid.

- Pressure test: Both bioreactors were filled with water up to 50%. After that a constant pressure of one bar was given to bioreactors to proof if gas could remove out of the system. This was measured with help of pressure sensors. This guarantees an exactly measure result in future actions.

- Temperature test: Referring to the pressure test both bioreactors were heated with the help of heating coils and it were tested if a permanent and constant heating is possible. This is important for a successful fermentation process.

- Pump test: The functionality of the pumps was tested with water too. Therefore water was filled into the mixing vessel and was pumped into the homogenizer and from there into both bioreactors.

- Test with homogenizer: The functionality of the homogenizer was tested with water and substrate and after that pumped into both bioreactors.

All mentioned tests were carried out manually because of non-integration of any automation software and hardware (e.g. sensors, computer controlled and automated processes, automated valves and control elements) for the time being. Nevertheless all functionality tests were successful. As soon as the inexistent software and hardware will be integrated some functionally tests will be carried out again to show that the automatic functionality of the prototype is warranted.

Task 3.3: System integration BIOWELL at end-user's side

The objective of this work-task was to integrate the high-pressure biomass pre-treatment system with the process control system from C-L into the end-users biogas plant. Involved in the integration of the prototype at CUTEC's side were DCU, GHM, BHR and DMS. The CUTEC supervised the assembling of the biogas plant and documented it with an assembling protocol.

The detailed component-list of the biogas plant is as follows:

- Reefer container: A reefer container guarantees an adequate storing of the sludge under ideal conditions. This is necessary as pre-stage for the converting by prototype.

- Pipes: An open-circuit water pipe and a sewer pipe were connected with the prototype. The open-circuit water pipe is necessary to supply the mixing vessel with fresh water. The sewer pipe drains the waste water off the fermenter.

- Cables: The cables for electric power supply were connected with the prototype. The power supply is necessary for powering the mixing vessel, the pumps, the homogenizer, the heater and engines.

- Measuring unit: During fermentation the produced biogas will be measured by a concentration measuring unit to assign the proportion of CH4, CO2 and H2S. At the same time the volume of the produced biogas will be measured.

- Gas pipeline1: The biogas will be transmitted from the fermenter to a gas tank.

- Gas tank: The produced biogas will be retained in a gas tank for further utilization.

- Gas pipeline 2: The biogas will be transmitted from the gas tank to an energy demonstrator.

- Engine demonstrator: With the demonstrator it will be possible to generate electricity and to measure the generated KW.

For the moment, the biogas plant is functional but some small parts still have to be integrated. As noted above (Task 3.2) some units for the automation are not integrated at this time, however this has no influence on functionality of the biogas plant. Moreover the energy demonstrator isn't available yet but it will be connected as soon as possible. After connecting the demonstrator it will be possible to collect and evaluate the capability of the biogas plant in KW. It can be concluded that a better part of the integration has been carried out successfully and with minor assemblies necessary for demonstration start up, the plant will certainly be operated during the next months.

2.3.3 Deviations from the work program and corrective actions

During the achievement of work package 3 some positive aberrations have been carried out. For reducing further delays all partners decided to assemble and integrate the prototype at CUTEC's side. This was done to reduce the route of transport and therefore, the carriage of the components (e.g. homogenizer, components, process control system etc.). Furthermore the existing infrastructure at CUTEC's side ensures an ideal condition for a successful operational procedure and an effective cooperation of the partners. The CUTEC itself has the necessary know-how and competence to accomplish potentially occurring challenges. With this previously action it was possible to anticipate a new time lag and to minimize the costs of transportation and long ways for the project partners especially these ones who have their company domiciled in Germany. All together, these corrective actions led to a cost and time efficient resource management and pushed the project significantly forward.

2.3.4 List of Deliverables

No.	Title	Scheduled	Status	Date
D09	Design and component list for prototype construction	Month 12	Completed	March 2008
D10	Report on prototype test	Month 16	Completed	June 2008
D11	Assembling and prototype evaluation report	Month 18	Completed	July 2008

2.3.5 List of Milestones

No.	Title	Scheduled	Status	Date
M03	Tested BIOWELL prototype	Month 17	In progress	

With the process and engineering data from the second work package, the prototype was effectually constructed in the third work package. First tests with the prototype were carried out. When the prototype will be successfully integrated and automated working with the connected biogas-plant, the milestone M 03 will be achieved.

2.4 Work package 4: Demonstration phase

2.4.1 Objectives and starting point of work at the beginning of the period

Work package 4 contains the demonstration test protocols, procedures, definitions, execution and evaluation of results from the BIOWELL prototype. WP4 defines and helps to explain the results obtained, show the success and workability of the plant by the end user as defined in the user requirements. This involves first the definition of the demonstration test procedures, followed by the execution of the demonstration test, test data evaluation and final planning of the commercial units as described in the commercial plan outlay. The extension period was beneficial to the completion of WP4 as this period was used to correct deviations and take corrective actions to the full functioning of the plant through the demonstration test.

2.4.2 Progress towards objectives

Task 4.1: Definition of demonstration test procedures

This is to certify quality assurance and control issues and put the system to trial using the pre-defined testing performance parameters. The demonstration test was coordinated in real time industrial conditions with the observation and support of the construction partner GHM. This includes a failure free test run at the end users-side and more so, more prototype hardware tests were carried out to ascertain its functionality. With the aid of the evaluated data from the partners the commencement of the definition of demonstration phase was made possible. This process put the following procedures into consideration:

- Prototype Scale-Up for Demonstration Test
- Testing Descriptions

Task 4.2: Execution of Demonstration Test

The Prototype test was performed to test-run the plant in order to simulate its working conditions in a typical situation. Also this is to carry out analyses that would aid the monitoring of the biogas plant for the end user demonstration phase. The test was divided into two phases:

- Testing with water at the first instance
- Testing with a Biomass feed to simulate a large scale industrial process

Some of tests are listed below:

- Hydrostatic test
- Flow path test
- Pressure test
- Temperature test
- Pump test
- Test with homogenizer

Task 4.3: Test Data Evaluation

Testing the plant with the feed was to enable us evaluate results for corrective measures where necessary. The test was also carried out to determine the influence of the particle size in substrate chaffed maize. Also it has been shown that in a homogeneous situation, powdery alloy silo-maize-sample which appears at sampling and sample allocation to the different fermentation reactors is lower than at fresh material which as well contains lumpy and fibred organic properties. These results demonstrate that the enhancement of the gas yield by homogenization of biomass seems to be possible. The following factors are the main ones influencing the biogas production. The following biomass parameters are the main ones influencing the biogas production.

- Substrate highlight
- Homogenization Evaluation
- Digestate (Maize and Rye Silage)
- Digestate (Slurry and Butchery Waste)
- Ultrasonic Batch Fermentation
- Anaerobic Digestion Batch Experiments (Substrates)

2.4.3 List of Deliverables

No.	Title	Scheduled	Status	Date
D 10	Report on prototype test	Month 21	Updated and Completed	November 2008
D 11	Assembling and prototype evaluation report	Month 23	Updated and Completed	January 2009
D12	Report on testing performance	Month 22	Completed	January 2009

2.4.4 List of Milestones

No.	Title	Scheduled	Status	Date
M 03	Tested BIOWELL prototype	Month 21	Completed	December 2008
M04	Functioning BIOWELL pilot plant ready for demonstration tests	Month 24	Completed	January 2009

2.4.5 Deviations from the work program and corrective actions

There were no more deviation experienced at this point and all earlier deviations were taken care of. This extension period served as an avenue to correct the deviations and complete the testing performance process for final end user application. At this point, it can be seen that all the deliverables have been achieved and all the milestones reached. The extension period was beneficial to the completion of WP4 as this period was used to correct deviations and take corrective actions to the full functioning of the plant through the demonstration test.

2.5 Work Package 5: Project Management

2.5.1 Objectives and starting point of work at the beginning of the period

This package involved the coordination and administration of the entire project to meet deliverables and milestones. The disseminating plan has a strategy which is to transform the knowledge gained and make it accessible to the public and in this case, the end user and particularly to disseminate information that is understandable by the general public in a simple way to enable easy exploitation. It is hoped that the results will later constitute a knowledge bases that will enable the end user to have an overview of BIOWELL in solving energy problems through eco-friendly easy solutions. In this plan, CUTEC will be involved in the demonstration and balancing evaluation to test-run this technology to ensure quality assurance and control during exploitation. This will be closely followed by publications and issuance of project bulletins.

2.5.2 Progress towards objectives

Task 5.1- 5.2: Administration and Reporting

The lead project management team in conjunction with BIOWELL project managers have been in constant touch with all partners in the consortium and has established focal points to ensure effective supervision for the entire process. As would be seen in the attached appendices of this report, issues of finance and technical update about the project have been carefully highlighted. One of the aims is to enable knowledge sharing and accessible the end user and particularly to disseminate information that is understandable by the general public in a simple way to enable easy exploitation.

To strengthen personal contact and guarantee the transfer of project data and knowledge, several meetings were held at the sites of the partners. With partner visits at the site of the SME and RTD performers, the projects' progress and the potentials of every single partner was reviewed on a regular basis. In this section the activities of the RTD performers to assist the SMEs in solving their problems and give them new market potentials are described. From the results achieved so far, the end designed of BIOWELL is expected to constitute a knowledge base that will enable the end user to have an overview of BIOWELL in solving energy problems through eco-friendly easy solutions. The time-table is designed to be implemented beyond 2009 with a long term plan for its sustainability and improvement.

Task 5.3: Update on the Public website

The task of 5.3 was to design and set up a public website for the purpose of this project. The project management team then used available technical information and resource to develop a web site suitable for the exploitation of Biowell and its progress. To meet the objectives of a project like this, the website will be used to market, manage and in the future, it will be used to facilitate the integration of a full-scale e-commerce and Biowell project management solutions.

The website will be an excellent channel for promoting Biowell potential to clients anywhere, anytime as the website address can be accessed from a business card, adverts, letterheads, emails and search engines. It offers a cost effective and convenient means of keeping in touch with your existing client base and keeping them informed of developments within the project. This is achieved without visiting the printers, or mailing hundreds of letters. The project team has decided that we have to gather contact details and information about visitors to the site (in the future), as this will be useful for trading on-line and can be used as a virtual shop window enabling Biowell to compete on much more equal terms with much larger projects.

Future plans for the website and progress towards objectives

The entire consortium has the desire to use this website to achieve a long term plan for this project and furthermore generate the required awareness in line with the scope of work and objective for which this project was established. This website will be managed to add the following advantages:

- Efficient, interactive channel for communicating with customers and suppliers
- Efficient form of internal communication
- Customers can be kept informed of project and product changes through electronic newsletters
- Promote your website through e-mail by including a link
- E-letterheads / e-stationery can enhance your image
- It is cost effective - no postage, printing, envelopes or stationeries for updates

The future of e-commerce has come and projects like Biowell will benefit in this regard as more and more people now prefer internet access as a more convenient way of daily live and for availability of variety of goods and services. The Biowell website is open to suggestions and opinions on how we can improve it better in order to effectively integrate it into the entire process.

Task 5.4: Dissemination Plan

The information generated from the BIOWELL project is intended to generate academic communication, industrial knowledge sharing (from patent rights) and a basis for future research. All these channels normally leads to some type of formal publication, which will eventually make the results, findings, observations and views arising from the researcher's work public. Normally, these will take the form of printed material in journals, publications, bulletins and similarly another route planned for disseminating the results obtained from BIOWELL is through the soft media which include the internet (BIOWELL website, press conferences, media interview etc).

The plan for information dissemination for this project is intended to achieve the following objectives:

1. Information about BIOWELL can be spread to a widely scattered group outside and beyond the end users.
2. Detailed information such as descriptions of methods, tables, diagrams, results, etc, can easily be made available for easy access.
3. The final printed documents should contain information, which can be critically examined and verified which should include issues of Patent rights.
4. Published documents should provide a means for establishing the merits of academic work, and thereby contribute existing works in the field of bio- fuels, energy and biotechnology.

Electronic Mail and Electronic Conferences

Informal and formal electronic communications gives a rapid and relatively inexpensive method of direct communication between people or groups of people as displayed throughout the course of the BIOWELL project.

The BIOWELL project will exploit and use the advantages given by the electronic media since this means of Communication is independent of global time differences and can take place even without the receiver having to be in place in contrary to phone calls. We intend to use this hybrid approach to continue in the exploitation and dissemination of the BIOWELL prototype down to the final delivery date. The electronic means can be achieved through:

- the electronic media, It is easy to transmit text documents
- mails can be printed and stored if required

Also for the all important aspect of commercialisation of BIOWELL, the electronic media will be used to provide electronic conferencing facilities between users, marketers and project coordinators irrespective of the location. An example is the skype call conferencing among others now in existence, which can be used for dissemination of information, results and exploitation of the entire BIOWELL project throughout its life span.

NOTE

The use of modern electronic media has been intensively used to reduce travel activities, which helped to save the projects rare resources of budget and time**.**

Oral Communication Channels

In the past, the main forms of informal communication in science, technology, medicine etc. have been through verbal communication channels - personal contacts with colleagues and teachers - seminars, lectures, and discussions at conferences, fairs etc. In this regard, the BIOWELL project intends to explore this natural means of communication to share the results achieved within groups and also on personal contact basis with external parties. This would further yield the following advantages:

1. it is a fast useful way for obtaining very recent unpublished information especially during meetings and within discussion groups
2. are based on two-way communication and therefore, promote an understanding of the real information need(s) and the communication of relevant information
3. oral communication is very flexible and promotes real time knowledge sharing simplifies and facilitates the transmission of information between people working in different subject areas which is one of the aims for BIOWELL

Role for SME's in Dissemination Plans

SME's will participate and have been incorporated into the disseminating plan in the following forms:

- The consortium has identified a number of SMEs that will be incorporated into the dissemination and exploitation phase of the project. The aim of this step is to create new knowledge or produce results with clear potential to improve or develop new products, processes or services for the participating SMEs.

- To help SMEs identify and address common technical problems and to promote the effective dissemination of results. This will help and empower SMEs technologically and enable them develop for future industrial challenges.

- The exploitation aspects will also provide supportive networks of intermediaries and schemes to encourage and facilitate the participation of SMEs, this will bring encouragement to the participating SMEs and results exploited will be sustainable.

Task 5.5: Exploitation Plan

Biowell results will be exploited for use and benefit to the EC reach out areas, end users, SME's and the academic community. It is aimed that this project will be exploited to make available real time data during its usage for quality management concerns and monitoring. The exploitation manager assigned for this project will coordinate the strategies that will be highlighted in the table below:

Table 3: Illustrating the exploitation time-table and schedule for BIOWELL. Note that some of the scheduled activities have already been completed and highlighted in grey.

Planned / Actual Dates	Type	Type of Audience	Country addressed	Size of Audience	Partner responsible / involved
2006 - 2009	Project's web page	General public, Research, Industry, Authorities	Industrial Countries		CUTEC with contribution of all partners
2006 - 2008	Involvement of Students	Students	Germany, Czech republic, Ireland	Total around 30	CUTEC, DCU, CVUT

2008	National CHISA Conference	Researchers	Czech republic	Total 350	CVUT
2007 / 2009	Int. Conference on Sustainable technologies	Researchers	Russia	120	CVUT
2009	International CHISA Conference on Mixing aspects of bioreactors	Researchers	Czech republic		CVUT
2008	13th European Conference on Mixing	Researchers	Italy	220	CVUT
2.-5.4.2008	ANUGA FoodTec	Researchers and industrial Engineers	Germany		DMS
March 2009	Kölner FoodTec Tage – Kongress	Researchers and industry	Germany	150	DMS
17./18.10. 2008	DECHEMA Koferenz der Biotechnologen	Researchers and industry	Germany		CUTEC
2006	International OSCHI Conference	Researchers	Slovakia	Total 300	CVUT
13.9.2007	Biogas-Sysmposium Hildesheim	End-user, Farmers, Researchers	Germany	180	UBF
11.12.2007	Jahrestagung BIOGAS und BIOENERGIE in der Landwirtschaft, Weckelweiler	End-user, Farmers, Researchers	Germany	250	CUTEC

Partner GHM has been assigned the responsibility to cooperate with Biogas plant distributors and release this information in company brochures and bulletins. This will be carried out in collaboration with DMS who will establish a new product line for the biomass homogenizer and also cooperate with biomass plant distributors.

In order to meet the objectives of the deliverables and ensure that the exploitation plan is achieved, we have marked out avenues to be used in supporting the business strategy for BIOWELL. Apart from using the results, patents right and eventual operation of the system for energy purpose, we also looked at marketing and branding as an exploitation avenue. These areas are the internet, brand marketing, marketing events and seminars which will include trade fairs, road shows, exhibition and marketing sales training for end users and other target users.

Business and Commercialisation Strategy

A comprehensive analysis has shown that the market regions for BIOWELL will definitely grow beyond Europe in the future and this calls for a wider commercialisation planning as would be seen below.

Commercial Plans

- Marketing mix which is a combination of marketing tools that are used to satisfy customers and stakeholders objectives which also involves developing a successful marketing program for BIOWELL and its relating technologies.
- mission statement for the project to reflect the purpose of BIOWELL

Commercial Model

The Commercialization stage will focus on entry into the market and early sales activity of the project if necessary. This model is to implement early strategies to sell the idea to the marketing public, end users and the media.

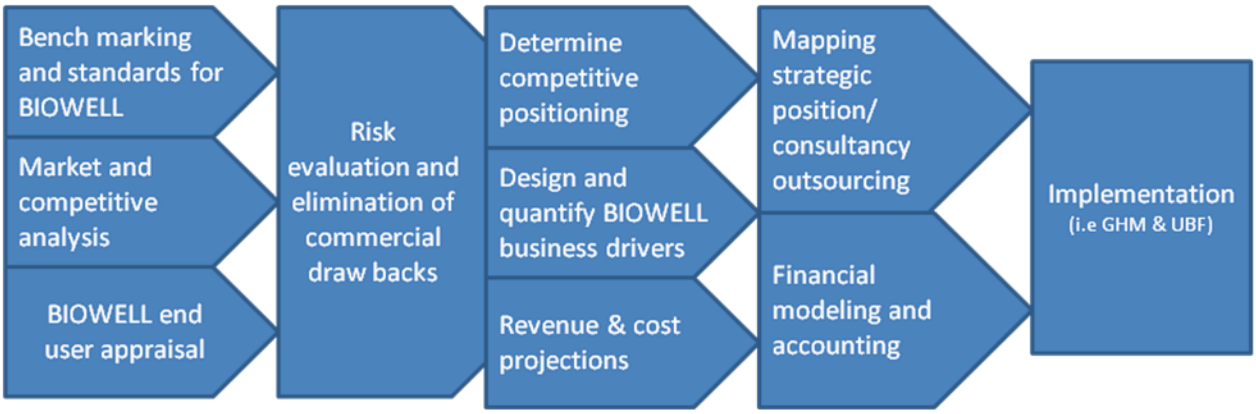

Figure 4: Commercialisation Model for BIOWELL

The purpose of this model is to ensure:

- Preparation of an information management sheet for the commercial stage
- For efficient financial accounting and economic planning
- To launch BIOWEL and results into the market and achieve sales targets
- To deliver quality product on a timely basis to the market
- To put in place information systems to monitor commercial operations

At every stage, it is expected that a commercial benchmark and standards for BIOWELL would be defined as stated in the project economics earlier.

SME's Input

Using the SMEs as an exploitation avenue for BIOWELL is in the bid to support SMEs in participation in research, marketing and other entrepreneurial activities relating to this project. We believe that this will add a significant value to EC's support for SMEs with similar measures launched to monitor the impact of participation in SME and its overall progress and benefits to projects like BIOWELL and others. The program out lay for SMEs into BIOWELL is in the following forms:

- The consortium has identified a number of SMEs that will be incorporated into the dissemination and exploitation phase of the project. The aim of this step is to create new knowledge or produce results with clear potential to improve or develop new products, processes or services for the participating SMEs.

- To help SMEs identify and address common technical problems and to promote the effective dissemination of results. This will help and empower SMEs technologically and enable them develop for future industrial challenges.

- The exploitation aspects will also provide supportive networks of intermediaries and schemes to encourage and facilitate the participation of SMEs, this will bring encouragement to the participating SMEs and results exploited will be sustainable.

We are confident that this can be achieved soon because SMEs also make an important contribution to overall employment, accounting for 60-70 per cent of the manufacturing total in most developed and fast developing economies.

2.5.3 Deviations from the work program and corrective actions

During the cause of execution of the project, we had some deviations from the original plan and schedule. We would like to highlight these deviations here with corresponding measures already taken to meet deliverable objectives.

- There was a redesign for addition of process control equipments for the automation process. This is as a result of further test and trails being carried out and to raise the life-time and efficiency level of the automatic system. The absence of these additional components and finance has delayed the completion of the process control assembly.

- These components include automatic valves, sensors and other process parts, which have delayed the prototype test within 24 months.
- So far, we have made huge successes and we are confident that the project will exceed expected standards.
- Another solution here is that we have on hand, additional personnel to help speed up the various integral processes so as to meet up with project timings and schedule.

List of administrative and technical meetings that have taken place between the partners:

Meetings	Location	Date	Participants
Kick-Off	CUTEC, Clausthal	06.02.07	All Partners
Technical	DCU, Dublin	10.04.07	UBF, BHR, DCU
Administrative	BHR, Cranfield	26.06.07	BHR, CUTEC, DCU, UBF, CVUT
Scientific, Admin.	CVUT Prague	1.7.2008	CVUT, CUTEC, DCU
Administrative	CUTEC, Clausthal	22.1.2009	C-L, CUTEC, DCU, UBF, CVUT
Final Meeting	CUTEC, Clausthal	8.5. 2009	All Partners

Note: an appraisal meeting was scheduled for beginning of 2009 to review progress of the project and take corrective actions on deviations. This was done to add momentum to the overall project success. This meeting was both on technical and non-technical matters relating to the planned extension of the project (Demonstration phase).

The project management and coordinating team used modern day technology and media for meetings and information sharing which proved very useful to the overall benefit of the project

2.5.3 List of Deliverables

No.	Title	Scheduled	Status	Date
D13	**Demonstration test protocol and test data evaluation**	**Month 30 (extension)**	**completed**	**August 2009**
D14	**Analysis of results to be protected by patients**	**Month 12**	**Updated continually (section I)**	**Summarized in Mai 2009**
D15	Draft plan for using and disseminating knowledge	Month 12	Updated and Completed	January and December 2008
D16	Six months progress report	Month 6	Completed	January 2008
D17	18 months progress report	Month 18	Completed	October 2008
D18	Plan for using and disseminating knowledge	Month 24	Completed	December 2008

2.5.5 List of Milestones

No.	Title	Scheduled	Status	Date
M05	Midterm assessment report	Month 12	Achieved	September 2008
M06	**Final Report**	**Month 30 (extension)**	Achieved	**August 2009**

Section 3: Consortium Management (Deviations and corrections)

3.1 General Deviations

The first deviation was experienced with the kick-off meeting in February 2007, which had already delay the project by two months, instead of the project starting in late autumn (November 15th) 2006, it was not possible to bring together the whole consortium and to get started in 2006.

The testing procedure was changed during the project in order to save time because of the already occurred delay from the late project start and work package 1. The main change was to make available additional resources (personnel and material) at the research partner's side (CUTEC, CVUT and DCU).

Additional technician were employed by UBF and two more students were included in the project work by BHR to corrective the delay in the starting date. With these efforts, the delay was reduced to the half and the work package 1 was successfully completed at thr end of month 4 instead of month 3 as calculated in the work program.

Some delay occurred in the achievement of some deliverables due to a delay in obtaining the relevant information. There was no much additional corrective action in work package 2 to reach the set goals.

There was a reduction in GHM MM worked in WP 1 so that the partner can just concentrates on WP3 to fasten the prototype construction procedure.This lead to high efficient laboratory test procedures and only a minimum of new construction of test-equipment was needed from GHM.

During the process of achieveing work package 3 all partners agreed to the assembling and integrating of the prototype at CUTEC's side to reduce further delays. These delays can be attributed to route of transport, the carriage of the components (e.g. homogenizer, components, process control system etc.).

There was a redesign for addition of process control equipments for the automation process. This is as a result of further test and trails being carried out and to raise the life-time and efficiency level of the automatic system. The absence of these additional components and finance has delayed the completion of the process control assembly.

There was a six (6) months extension period for the project, which served as an avenue to correct the deviations and complete the testing performance process for final end user application.

3.1.1 CUTEC and C-L Deviations

As CUTEC proceed to assemble the testing and demonstration protocols, there was a shortage of man power and more personnel were needed. The urgent need and out sourcing of more staff brought about a pause and delay in days. There were also some obstacles in the prototypes part fittings as we proceeded to couple the testing performance together. The estimated time for the test was not sufficient as we had to alter the process set-up to accommodate the analysis. At this point, we saw the need to upscale and allow more time for the fermentation process. More un-planned task led to a shortage in budget for the execution of the some vital assignments. The shortage of finance resulted in these delays as it was necessary for finance to be injected in the project to meet deadlines. Similarly, as slight modifications came up, the prototype needed some changes to contain the assembly design and fit the materials used for testing and general plant components integration.

We experienced these delays which also affected the logistic and planning schedules. The project management team also had to put forward some meetings as the sequence of the demonstration was slightly impeded through these deviations.

3.2 General Corrective Actions

1. Prototype construction at CUTEC's side

During the delayed prototype construction phase it became more and more evident that additional personnel and technical resources were required to compensate the late stage in the project. The original planned construction partner GHM could not generate these additional efforts so the coordinator suggested the construction of the plant at CUTEC. CUTEC as a full-equipped research institute offered multiple possibilities to mobilize additional staff and all other required resources to realize the prototype construction with time and cost efficiency. The consortium agreed to this and the construction partners supported the plant manufacturing at CUTEC which was commendable. This however helped to reduce the construction time and projects delay.

2. Request for additional payment

Regarding the additional efforts the partners had to take over, some partners ran empty with their budget. And further not to hinder the project due to lack of money, we formally asked our "financial and administration" officer Cristina Tatu-Caravan for an additional payment who agreed with requirements (see e-mail conversation of 14.10. 2008 with Onyeche).

3. Prototype Budget Shift

CUTEC took over the ordering equipments from other construction and research partners to help minimise cost to accommodate budget shift. This concerned mainly the "data transfer and presentation system" from C-L, the "technical scale reactors" from GHM and the "high-pressure homogenizer in technical scale", which originally should be provided from DCU. Therewith, the costs and delivery-times could be reduced drastically as benefit to the project and consortium. The partners agreed to adjust these additional expenses of CUTEC and to consider the cost in their actual Cost Statements. This procedure has also discussed with our "financial and administration" officer Cristina Tatu-Caravan at e-mail conversation of 18.9.2008 with Schläfer. In table B.6-2 from the "description of work" (a copy of this is given below) the original planned resources of the prototype construction are given (see "prototype costs"). It has been agreed with C-L, GHM and DCU to shift a part of their originally planned budget of this prototype costs to CUTEC (depending on the tasks CUTEC took over). In table B.6-2 (1) below the planned internal shift of the prototype budget is demonstrated. Table B.6-2 (2) gives the result of this shifting procedure. These financial aspects will also be clearly given in the following "Report on the distribution between contractors".

4. Project extension

As seen from the Deliverables and Milestones, all planned project tasks have now been completed in the 30 months project run-time and also accommodating the demonstration phase. This phase is seen to be extremely important for the total outcome of the project, especially the planned commercialization of the results by the SMEs. This was further made possible through the project officers Mrs. Tatu-Caravan and Mrs. Impens.

Table B.6-2 from Annex I (Description of Work): Original planned resources for the BIOWELL project

Partner Name	Resources		Over-heads	Description	Consumable	Description	Proto-type	Description	Travel and subsistence	Description
	MM	Total costs	costs		costs		costs		costs	
CUTEC	55	342.190,25	83.813,05	25 % on all direkt costs	4.000	Chemicals for analysis of the biomass to determine and control the effect of the pre-treatment	25.000	Construction of the measuring device from laboratory small scale up to industrial process technology	4.500	3 formal meetings and additional work meetings
C-L	21	155.543,36	25.840,56	20 % on all direct costs	4.000	Circuit boards, negative films and chemicals for board development, electronic cupboards, insolation materials	15.000	Data transfer and presentation system via internet, alarm and diagnose system, distant plant control operation equipment	4.500	3 formal meetings and additional work meetings if necessary
GHM	40	256.212,50	42.618,75	20 % on all direct costs	4.000	Welding material, screws, seelings and mounting material for large scale reactor, fermentation liquid for pre-tests	11.000	Technical scale reactor for integration of prototype disruption system and first fermentation test experiments	4.500	3 formal meetings and additional work meetings
DMS	28	165.833,12	27.555,52	20 % on all direct costs	3.000	Ceramic materials, valves and seelings for homogenizer optimization	12.000	High pressure homogenizer and related apparatuses (e.g. macerator, pumps etc.) in laboratory scale	4.500	3 formal meetings and additional work meetings if necessary
UBF	32	205.740,80	34.206,80	20 % on all direct costs	2.000	Nutrients for demonstration of large scale fermentation experiments	8.000	Adaptation of an existing large scale industrial fermentation reactor for pre-treatment system	4.500	3 formal meetings and additional work meetings if necessary
BHR	11	225.543,85	128.165,85	159 % on staff	3.000	Materials for implementing the measurement and data acquisition equipment, chemicals for lab-scale analysis	12.000	Data acquisition system, measurement equipment, data processing and evaluation systems	5.000	3 formal meetings and additional work meetings if necessary
DCU	48	320.203,78	53.367,30	20 % on all direct costs	5.000	Materials for completing the laboratory reactors, nutrients for fermentation in laboratory scale	75.000	Technical scale high pressure homogenizer, digestion reactor, macerator, pumps	5.000	3 formal meetings and additional work meetings
CVUT	40	250.152,00	41.692,00	20 % on all direct costs	2.000	Welding equipment, stainless screws, special glou for the connection of ultrasound transducers	25.000	Ultrasonic transducers, generator and amplifier. Ultrasonic prototype reactor in technical scale	4.500	3 formal meetings and additional work meetings
SUM:	**278**	**1.921,416**	**437.259**		**27.000**		**183.000**		**37.000**	

Table B.6-2 (1): Extract of B.6-2 with suggested shift of the prototype budget

Partner Name	Proto-type Costs [€]	Description
CUTEC	25.000	Construction of the measuring device from laboratory small scale up to industrial process technology
C-L	15.000 minus 10.000	Data transfer and presentation system via internet, alarm and diagnose system, distant plant control operation equipment
GHM	11.000 minus 10.000	Technical scale reactor for integration of prototype disruption system and first fermentation test experiments
DMS	12.000	High pressure homogenizer and related apparatuses (e.g. macerator, pumps etc.) in laboratory scale
UBF	8.000	Adaptation of an existing large scale industrial fermentation reactor for pre-treatment system
BHR	12.000	Data acquisition system, measurement equipment, data processing and evaluation systems
DCU	75.000 minus 50.000	Technical scale high pressure homogenizer, digestion reactor, macerator, pumps
CVUT	25.000	Ultrasonic transducers, generator and amplifier. Ultrasonic prototype reactor in technical scale
SUM:	**183.000**	

Table B.6-2 (2): Extract of B.6-2 with the results of the internal prototype budget shift

Partner Name	Proto-type Costs [€]	Description
CUTEC	95.000 (Plus 10.000) (Plus 10.000) (Plus 50.000)	Construction of the measuring device from laboratory small scale up to industrial process technology From C-L for: Data transfer and presentation system via internet From GHM for: Technical scale reactor for integration of prototype disruption system From DCU for: High pressure homogenizer in technical scale
C-L	5.000	Alarm and diagnose system, distant plant control operation equipment
GHM	1.000	First fermentation test experiments
DMS	12.000	High pressure homogenizer and related apparatuses (e.g. macerator, pumps etc.) in laboratory scale
UBF	8.000	Adaptation of an existing large scale industrial fermentation reactor for pre-treatment system
BHR	12.000	Data acquisition system, measurement equipment, data processing and evaluation systems
DCU	25.000	Technical scale digestion reactor, macerator, pumps
CVUT	25.000	Ultrasonic transducers, generator and amplifier. Ultrasonic prototype reactor in technical scale
SUM:	**183.000**	

3.2.1 CUTEC Corrective Actions

On the part of CUTEC, the last phase of completion was to tidy up areas that needed final attention and complete the demonstration test according WP4. This led to CUTEC taking corrective measures in addressing deviations to meet up with the miles stone of the last project period. CUTEC earlier planned 12 MM for WP 2 but due to project changes and need for additional expertise for purpose of efficiency, there was a deviation and CUTEC finally made 13MM. Similarly, for WP 4 CUTEC planned 14 but was able to achieve 13.

The demonstration phase in WP4 was an overlapping process from WP3, so we had to run all test intermittently from one process to another. CUTEC had to use is internal hall for this all-important process. The results evaluation from these entire tests was a critical procedure that needed accurate analysis and in this regard, we had the need to require the services of more scientific staff of high distinction in this field. These included academics with rank of PhD and Professors to help speed up the delivery as this was part of an earlier contingency plan. It is important to clarify that the costs for CUTEC personnel rose to a value around 30.000 Euros, which is higher than the calculated value. However, the total number of MM still remains the same but with an increase in cost. This is because of the difficulties encountered along the line in terms of additional man power, extra equipment and specialties required for the demonstration test at CUTEC.

Additional personnel and ad-hoc persons were required as we entered some critical points of the testing and evaluation and were charged with the task of running quality checks on results during the performance and verification of the test. All these activities needed special arrangements and these experts were additionally hired and incorporated into the phase. This proved very useful and it helped to enhance our efficiency for the overall project success. As we incorporate these contingencies, we were able to work within the boundaries of the MM and the only change was an increase in manpower, staff and personnel needed to meet with project demands. These additions therefore, made the personnel costs higher and also are reflected in the project finances and therefore, included in this report.

3.2.2 C-L Corrective Actions

Since the process control components make up the heart of the functioning prototype, additional resources were employed to run a quality check to ascertain the final results. In work package 4, the role of C-L was very important especially for execution and test data evaluation. Due to project and test demands, the amount of work needed for WP 4 exceeded the planned duration and certain adjustments were made from the side of C-L.

- The needed time to carry out the requested measurements was more than expected due to the large variation of measured parameters. This required quality assurance method that sometime made the test to last for longer durations. And once the standardised scale was reached in the running, we proceed to record and examine the demonstration analysis.

- By standard testing procedures, we needed to carry out a second testing and a second attempt was made, where a new scalable measurement unit was used which yielded very useful results and similarly a learning curve. This is one of the highlights of the testing as the second testing is more like a benchmark process and proved the demonstration and result to be correct.

The additional measurements were to evaluate the integration of the process control system for controlling and regulation of the prototype as described in WP2. This corrective measure was to again ensure the integration and functionality to assure a failure-free data transfer and regulation of every single part of the prototype by the end user. This step was very necessary to consider the process control integration into the prototype finished as it now stands.

Finally, we are set to launch the Biowell project into its eventual usage at the end users side. All the project phase has been concluded and has addressed all the activities in WP1 to WP5, though with additional time which enabled the team time to work on the deviation and in turn take corrective actions. The team work proved beneficial and all parameters are confirmed.

Section 4: Other Issues

In this section the activities of the RTD performers to assist the SMEs in solving their problems and give them new market potentials are described. The table below gives a summarised overview about the work of the RTD performer done for the SME. Detailed information can be found in the deliverables.

	CUTEC	DCU	CVUT
C-L	Scientific and project management, development of the control system	Small—scale investigations regarding the sensors and control systems	Integration of sensors and process control systems in laboratory digestion fomenters
GHM	Plant construction support, lay-out of the technical components	Laboratory experiments for macerator optimization	Plant design and sketches for all relevant technical parts to be integrated in the prototype
DMS	Definition of the technical requirements especially the lay-out of the homogenization equipment	Homogenizer treatment experiments to find out the optimal process conditions for integration into biomass treatment	Pre-treatment laboratory-scale experiments with macerator and ultrasonic irradiation
UBF	Compilation of the end-users requirement	Economical calculations on energy and efficiency	Up-scaling calculations for prototype design
BHR	Fluid dynamic investigations as an impact of reactor design	Definition and evaluation of process parameters to be adjusted	Sensor interfaces and process communication

Balance of work / resources

The following table will give a summarised overview on the balance of work and resources done by each partner:

	Work Carried out	**Recourses made available**
CUTEC	• Administrative and scientific project management • Design and set-up of public web side • Definition of lab-test procedure • Design of control system • Compilation of the end-users requirements and legislation	*Personnel: Operative and financial director* Consumables
C-L	• Supporting the team in questions of sensor interfaces and process communication • Consultancy regarding the development of the universal process control system • Development of the data transmission • Providing communication capabilities to the BIOWELL control system	*Personnel: Development engineers and programmers* Consumables, soft and hardware
GHM	• CAD-Drawings of the prototype • Description and material lists of the prototype • Components construction details • Manufacturing of the prototype	*Personnel: Engineers and Technicians* Consumables
DMS	• Devising of the adaptation of the homogenizer to the prototype • Consultancy regarding the development of the pre-treatment system • Out-lining the overall capabilities of the prototype	*Personnel: Project Engineer, Technician, laboratory Assistant*
UBF	• Requirements of the end-user • Research on legislative and economical standards for calculation • Preparation of mechanical plants and components	*Personnel: Project Manager, Technician*
BHR	• Carrying out background survey on research done in the field of bioprocess activation and on the effect on pre-treatment apparatuses • Outlining the plans for universal bioprocess activation systems	*Personnel: Engineers, Technicians*
DCU	• Definition of technical requirements • Definition of lab-test procedure • Carrying out the small-scale analytical batch digestion experiments	*Personnel: Engineer, Lab Assistant, Students* Lab-test materials
CVUT	• Definition of lab-test procedures • Compilation of the technical requirements • Carrying out laboratory ultrasonic experiments and optimization procedure	*Personnel: Engineer, Lab Assistant, Students* Lab-test materials

Annex I - Plan for using and Dissemination of Knowledge

Section I - Exploitable Results

This section will only present exploitable results, defined as knowledge having a potential for industrial or commercial application in research activities for developing, creating or marketing a product or process or for creating or providing a service.

No.	Exploitable Knowledge	Exploitable Products or measures	Sector(s) of Application	Timetable for Commercial use	Patents or other IPR Protection	Owners or other Partner(s) involved
1	BOWELL system	Whole BIOWELL plant in all scales	Energy generation at municipal waste water cleaning plants and technical biogas plants	2008 - 2009	Not yet	UBF, GHM, DMS
2	Sale of BIOWELL system	Ultrasonic bye-pass-loop system	Waste water treatment, energy recovery from biomass	2008 - 2009	Not yet	UBF, GHM
3	Sale of BIOWELL system	Homogenization pre-treatment system	Food and beverage production	2008 - 2009	Not yet	UBF, GHM
4	Effect of Ultrasound on anaerobic fermentation systems	Bioprocess studies on hydrodynamics, basic research	All related industrial processes such as bioprocesses, pharmacy industry and food processing	2009 - 2012	Not yet	CUTEC, DCU, CVUT
5	Effect of homogenization on anaerobic fermentation systems	Fundamental effects on high-pressure processes on biomass	Anaerobic and aerobic treatment processes, basic research	2009 - 2012	Not yet	CUTEC, DCU, CVUT

Section II - Dissemination of Knowledge

In the following table information on the planned / achieved dissemination activities are given.

Planned / Actual Dates	Type	Type of Audience	Country addressed	Size of Audience	Partner responsible / involved
2006 - 2009	Project's web page	General public, Research, Industry, Authorities	Industrial Countries		CUTEC with contribution of all partners
2006 - 2008	Involvement of Students	Students	Germany, Czech republic, Ireland	Total around 30	CUTEC, DCU, CVUT
2008	National CHISA Conference	Researchers	Czech republic	Total 350	CVUT
2007 / 2009	Int. Conference on Sustainable technologies	Researchers	Russia	120	CVUT
2009	International CHISA Conference on Mixing aspects of bioreactors	Researchers	Czech republic		CVUT
2008	13th European Conference on Mixing	Researchers	Italy	220	CVUT
2.-5.4.2008	ANUGA FoodTec	Researchers and industrial Engineers	Germany		DMS
March 2009	Kölner FoodTec Tage – Kongress	Researchers and industry	Germany	150	DMS
17./18.10. 2008	DECHEMA Koferenz der Biotechnologen	Researchers and industry	Germany		CUTEC
2006	International OSCHI Conference	Researchers	Slovakia	Total 300	CVUT
13.9.2007	Biogas-Sysmposium Hildesheim	End-user, Farmers, Researchers	Germany	180	UBF
11.12.2007	Jahrestagung BIOGAS und BIOENERGIE in der Landwirtschaft, Weckelweiler	End-user, Farmers, Researchers	Germany	250	CUTEC