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Message from the Chair of the Executive Board

Dear Reader,

CenBio – the Bioenergy Innovation Centre – is one of the eleven Norwegian Centres for Environment-friendly Energy Research (FME). The FMEs are co-funded by the Research Council of Norway (RCN) for a period of eight years. This gives the centres a unique position, and the possibility to work strategically along long-term key R&D priorities and routes. We are grateful for the trust and support we have received from the RCN and the Norwegian government, and we are working hard to fulfil the CenBio vision – to develop the basis for a sustainable, cost-effective bioenergy industry in Norway in order to double Norwegian bioenergy use by 2020.

2010, the second year of operation for the centre, was an exciting year with many important results. CenBio's goals over the eight year period include ambitious targets for international publications, education, and innovation, and the centre has made great progress. In 2010, eight papers were submitted and published in reputed refereed journals, with two papers still waiting for publication. No less than 24 PhD and 5 Post Doc students were by the end of the year associated with the centre. Innovation is continuing to be at the core of CenBio, with an ambitious target of 25 innovations over the eight year period. During 2010 possible innovations were identified, an innovation workshop was held, and the first Bioenergy Innovation Award prize winner was selected. In addition, numerous conference papers, conference presentations and reports were produced. The reader will find the full lists for 2010 in this Annual Report.

Mitigating dangerous anthropogenic climate change continues to be a top priority on the global political agenda, and the CenBio management and staff are well aware of the important responsibilities and commitments that follow the FME appointment. CenBio's ambition is not only to provide basic bioenergy research and R&D solutions, but also to be active in the public debate and a moulder of public opinion. No less than 20 published popular science or debate articles in Norwegian press during 2010 speak for themselves.

Finally, I would like to thank the CenBio management and staff for a fruitful and exciting year.
I look forward with anticipation to the years to come.

Anne Karin T. Hemmingsen
Acting Chair, CenBio Executive Board
SINTEF Energi AS

Message from the Coordinators

Operating one of the eleven Norwegian Centres for Environment-friendly Energy Research (FME) is a challenging, but very rewarding task. We would like to express our gratitude to the Research Council of Norway (RCN) and the Norwegian government for initiating and funding the FME scheme, and to the CenBio Executive Board members who are working hard to help us realize the CenBio vision and goals.

During 2010, many important results and milestones were reached. Not only did the centre produce a high number of peer reviewed journal papers and reports, we were also very active on the international conference scene. CenBio researchers presented and published at conferences in Spain, France, New Zealand, Latvia, USA, Austria and Norway, and we have in addition found great inspiration in publishing no less than 20 popular science or debate articles in the Norwegian press. To strengthen scientific excellence, the Scientific Advisors (SA) committee was established during 2010, consisting of world recognized experts in the fields of each CenBio Sub Project.

Innovation is a key priority for the CenBio management, and we are finding the cooperation with our industry partners particularly fruitful. Part of the CenBio goals is to establish a strong Norwegian bioenergy industry and to supply consumers and society with more renewable and CO_2-neutral energy. In order to achieve this, direct interaction with industry and a strategy for increased innovations are essential. CenBio now has 17 industry partners, and we have opened up for additional industrial partners that could supplement the existing group.

The CenBio management and staff form a strong team that continuously works towards our highly set goals. To be part of this strong and dynamic group is very inspirational, and we look forward to the continuation.

Lars Sørum
Centre Coordinator
SINTEF Energi AS,
Coordination Institution

Odd Jarle Skjelhaugen
Deputy Centre Coordinator
Universitetet for miljø- og biovitenskap,
Host Institution

1 VISION AND GOAL

The vision of CenBio is to develop the basis for a sustainable, cost-effective bioenergy industry in Norway in order to achieve the national goal of doubling bioenergy use by 2020.

CenBio will address the entire value chains of virgin biomass and biodegradable waste fractions, including their production, harvesting and transportation, their conversion to heat, power and biogas, and the handling and upgrade of residues to valuable products. CenBio researchers will develop effective, environmentally sound ways of utilizing more biomass and waste for energy purposes. Educating and training the next generation of bioenergy researchers and industry players are essential to attain these ambitious goals.

As a result of the centre's activities, consumers will get access to different forms of environment-friendly energy, and society will be supplied with more renewable and CO_2-neutral energy. A further benefit will be the establishment of a Norwegian bioenergy industry and therewith a substantial number of new jobs, especially in rural districts.

2 RESEARCH PLAN

2.1 CenBio description

The overall objectives and principal work plan are explained in the centre description prepared during the application phase. The original description is referred to in the R&D Agreement between RCN and the host institution UMB. More detailed plan for the shorter term research activities is required, and an Annual Work Plan is to be submitted for RCN approval at the latest by 31 December each year. The Annual Work Plans will have to be based on the initial and less decisive description but course of the research may have to be changed due to external conditions.

2.2 Annual Work Plan

2.2.1 AWP2010

The planning of research activities for 2010 started in October 2009 when CMT met physically in Trondheim. All partners were invited to attend a work plan workshop at Ås 26 November, and input from those discussions were used to produce the draft AWP2011 that was presented for EB approval at its meeting in Sarpsborg 13 January 2010. Some formal requirements from RCN had to be implemented, and the revised version – Revision 1 – is dated 15 March 2010. On 18 March it was approved by RCN.

2.2.2 AWP2011

The planning of research activities for 2011 started in September 2010. All partners were invited to propose input to the plan, and to comment a draft version in October. The draft AWP2011 was presented for EB approval at its meeting in Oslo 25 November. Minor comments from EB were implemented and the final AWP was sent to RCN on 30 December.

Deadline for submission of AWP2012 to RCN is 1 December 2011.

3 ORGANISATION/COORDINATION

3.1 Partners

Initially there were 26 partners participating in CenBio. Universitetet for miljø- og biovitenskap (UMB) is the host institution and SINTEF Energi AS is the coordinating institution. The governance structure is further elaborated in section 3.2.

During 2010 two partners have withdrawn from the centre. Xynergo ceased to exist and AEB from the Netherlands decided to focus their research activities more on their core business.

The R&D Agreement between the Research Council of Norway and the host institution refers to two main categories of partners: Research partners and Industry partners.

3.1.1 Research partners

There are seven Research partners in CenBio:

- Universitetet for miljø- og biovitenskap (Host institution)
- SINTEF Energi AS (Coordinating institution)
- Norges teknisk-naturvitenskapelige universitet NTNU
- Bioforsk
- Norsk institutt for skog og landskap
- Stiftelsen SINTEF
- Vattenfall Research and Development AB (Sweden)

3.1.2 Industrial partners

The 19 Industry partners at the start of 2010 are shown below. The two written in grey left CenBio in 2010.

- Akershus Energi AS
- Norges Skogeierforbund
- Agder Energi AS
- NTE Holding AS
- Hafslund ASA
- Trondheim Energi Fjernvarme AS
- Norske Skogindustrier ASA
- Xynergo AS
- Norsk Protein AS
- Avfall Norge
- Norges Bondelag
- Oslo Kommune Energigjenvinningsetaten
- Afval Energie Bedrijft (Netherlands)
- Vattenfall AB, Heat Nordic (Sweden)
- Energos AS
- Cambi AS
- Jøtul AS
- BioNordic AS
- Granit Kleber AS

A list of short names used for convenience is shown in Table 8-11.

3.2 Governance structure

The governance structure as defined in the Consortium Agreement is shown in Figure 3-1.

The General Assembly (GA) consists of one representative from all partners, and meets physically at least once a year. All persons registered as CenBio personnel have access to the CenBio eRoom where they have access to all documents produced and planned events.

The Executive Board (EB) consists of seven members, three from Research partners and four from Industry partners. The Coordinating organisation appoints the chairperson.

Table 3-1: Executive Board members 2010

Position	Name	Affiliation
Chairperson	Mona J. Mølnvik	02 SINTEF-ER
EB Member (Research)	Ragnhild Solheim	01 UMB
EB member (Research)	Olav Bolland	03 NTNU
EB member (Industry)	Morten Fossum	13 STATKRAFT
EB member (Industry)	Rune Dirdal	17 AVFALLN
EB member (Industry)	Jon Iver Bakken	12 HAFSLUND
EB member (Industry)	Christian Ramberg	09 SKOGEIER

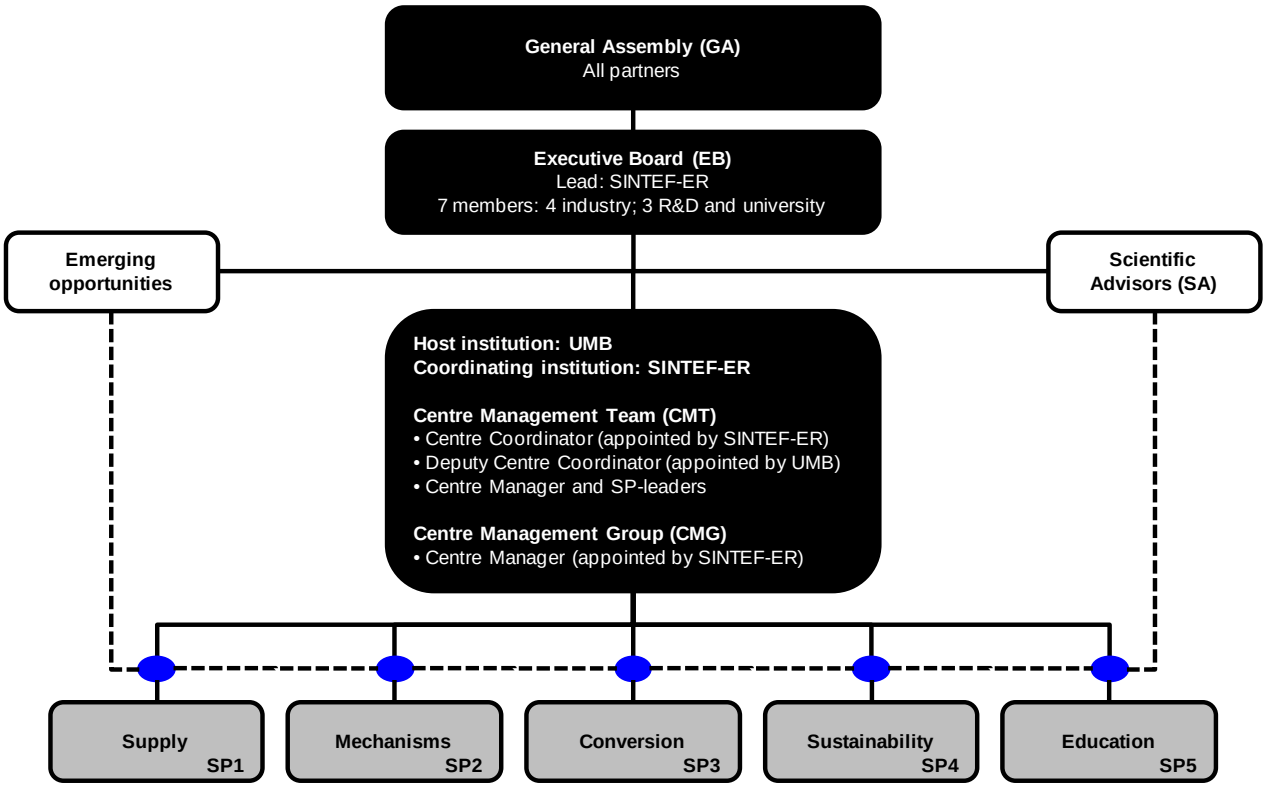

Figure 3-1: CenBio Governance Structure

The Centre Management Team (CMT) consists of the Centre Coordinator, the Deputy Centre Coordinator, the Centre Manager and the Sub-Project leaders. CMT is lead by the Centre Coordinator. CMT arranges regular meetings as required for coordinating the activities in the Centre

The Centre Management Group (CMG) consists of the Centre Manager and personnel dealing with financial, legal and other administrative issues. CMG is lead by the Centre Manager. The Coordinating Institution shall together with the Host Institution make available administrative personnel for the Centre Management Group.

Table 3-2: Centre Management Team

Position	Name	Affiliation
Centre Coordinator	Lars Sørum	02 SINTEF-ER
Deputy Centre Coordinator	Odd Jarle Skjelhaugen	01 UMB
Centre Manager	Einar Jordanger Michaël Becidan	02 SINTEF-ER 02 SINTEF-ER
SP1 leader (until 2010-07-31)	Simen Gjølsjø Hans Fredrik Hoen	05 NFLI 01 UMB
SP2 leader	Rainer Backman	02 SINTEF-ER
SP3 leader	Øyvind Skreiberg	02 SINTEF-ER
SP4 leader	Birger Solberg	01 UMB
SP5 leader	Anders H. Strømman	03 NTNU

Scientific Advisors (SA) were established during 2010, one for each Sub-Project except SP5. The four Scientific Advisors are shown in Table 3-3.

Table 3-3: Scientific Advisors

Sub_Project	Name	Affiliation
SP1 Biomass Supply and Residue Utilisation	**Heikki Pajuoja**	Dir. Metsäteho Oy
SP2 Conversion Mechanisms	**Mikko Hupa**	Prof. Åbo Akademi University
SP3 Conversion Technologies and Emissions	**Michael J. Antal, Jr.**	Prof. University of Hawaii
SP4 Sustainability assessments	**Pekka Kauppi**	Prof. Universitetet i Helsinki

3.3 Work Breakdown structure (WBS)

The technical activities within CenBio are organised in five Sub Projects (SPs) which again are divided into three to four/five Work Packages (WPs). A separate WP is defined to separate the management activities from the technical work. The WBS is shown in Table 3-4.

Table 3-4: Work Breakdown Structure

SP No	SP title WP No and title
SP0	**Centre Management and Coordination** WP0.0 Management
SP1	**Biomass Supply and Residue Utilisation** WP1.1 Feedstock supply WP1.2 Logistics WP1.3 Biomass and residue characteristics and uality WP1.4 Residue upgrading and use
SP2	**Conversion Mechanisms** WP2.1 Combustion WP2.2 Gasification WP2.3 Pyrolysis WP2.4 Anaerobic digestion WP2.5 KMB STOP: torrefaction
SP3	**Conversion Technologies and Emissions** WP3.1 Wood / pellet stoves WP3.2 District heat WP3.3 Heat and power WP3.4 Emissions
SP4	**Sustainability assessments** WP4.1 Life Cycle Assessment (LCA) WP4.2 Ecosystem management WP4.3 Cost assessment and market analysis
SP5	**Knowledge Transfer and Innovation** WP5.1 Bioenergy Graduate School WP5.2 Knowledge transfer and dissemination WP5.3 Innovation management

During 2010 the KMB project STOP focusing on torrefaction was integrated as an associated WP in CenBio.

3.4 Management and Coordination

3.4.1 General

The overall coordination activities are organised within a separate work package, WP0.1 Management and Coordination. During 2010 the main activities have been to reporting costs and progress, arranging coordination meetings, and to coordinate the planning of future research activities. Management within each SP is the responsibility of respective SP- and WP leader.

A project hotel was established in 2009 where all relevant documents are uploaded. Personnel from all partners have access to the CenBio eRoom. By 31 December 2010 approximately 120 persons had access to the eRoom. The overall structure of the CenBio eRoom is shown in Figure 3-2. The

folder structure is shown to the left. Folder 050 Meetings and 02 EB meetings have been expanded to show three levels as an example. Also folder 100 SP1 Supply and WP1.1 Feedstock Supply have been expanded to show the common structure for all SPs and WPs.

3.4.2 Meetings

The Centre Management Team had nine meetings in 2010, and the Executive Board had three meetings. The General Assembly met first time on 14 January in Sarpsborg. Most CMT meetings are arranged as teleconferences using eRoom for sharing documents and information.

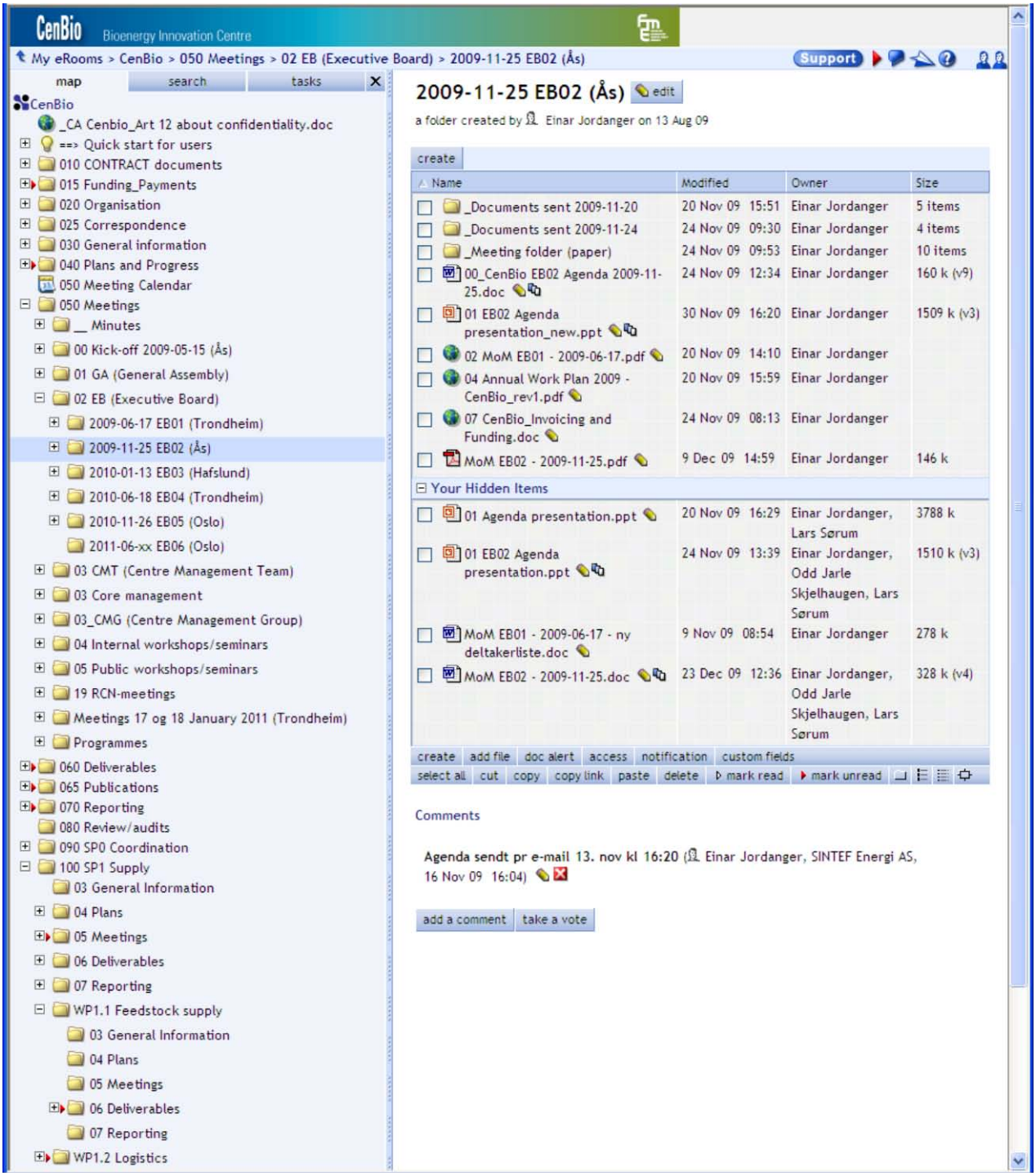

Figure 3-2: CenBio eRoom structure

4 RESEARCH ACTIVITIES

4.1 SP1 Biomass supply and residue utilization

4.1.1 WP1.1 Feedstock supply

WP1.1 has the responsibility of assessing and analyzing the current area and biomass availability, as well as analysing the long term production potential for biomass from forested areas for energy purposes. The activities follow two main lines of research;

i) Devolop new inventory methods for estimation of forest biomass and assess present biomass resources

ii) Analyse the linkage between biological production and potential, silvicultural management, economic behaviour, sustainability criteria and biomass supply by applying bio-economic optimisation models and econometric modelling.

A state of art report has been developed and research challenges ranging from basic silvicultural methods for production of biomass, via models and methods for biomass resources estimation, to decision support systems (computer programmes) for predicting biomass potential and availability have been identified. Two PhD-research proposals have been developed, i.e. “Development of decision support systems for long-term analyses of biomass” and “Development of models and methods for quantification of birch biomass”, and two persons have been recruited for the PhD-positions. Two journal articles, i.e. “Assessing current biomass resources in Norway” and “Assessing potential future biomass availability in Norway”, have been under development.

4.1.2 WP1.2 Logistics

WP1.2 provides assessments and undertakes research to provide unit cost assessments for different forest operation systems and how these vary with growing stock and site characteristics. This includes the evaluation, calculation and comparison of alternative logistic chains for bioenergy supply.

Results from the studies done in 2010 have been published in two reports; "Forwarding of forest residues" and "Stump harvesting - short trial". The first report concludes that forest managers should be aware of the ‘false economy’ of using conventional machines that appear to be loaded to capacity, but in reality are only operating at a fraction of their design specifications. Considerable savings can be made by using more appropriate (purpose built) equipment. The second report concludes that technically, there are no problems to extract stumps under Norwegian circumstances. While there are environmental considerations to be given the most important economic contribution of this resource is that it is located within the same geographic catchment area - i.e. a 60-80% increase in biomass yield with no increase in transport distance. This means that the resource simply cannot be ignored.

4.1.3 WP1.3 Biomass and residue characteristics and quality

WP1.3 analyses the variation among biomass fractions such as stem wood, branches, roots, bark, leaves and straw with focus on moisture content, calorific content, ash content, density, structure and chemical composition. WP1.3 also analyzes the impact of this variation on the practical fuel quality of new fuel fractions in their conversion to energy, to determine the level of upgrade or mixing these fuel fractions require to be converted to energy with high efficiency in low-costs installations.

In 2010, an abstract and a presentation were produced in D1.3.1 “Variations in Norwegian biomass properties end influences on bioenergy” and presented on a conference in Trondheim in June, 2010. Virgin wood and forest residues feedstock were combusted in SINTEF's lab-scale combustion reactor. The results will be published in a scientific journal during 2011.

4.1.4 WP1.4 Residues upgrading and use

WP1.4 provides research and analyse how the remaining residues when biomass is converted to energy may be best utilised and possibly recycled. This involves studies of upgrading, potential for use as input to produce fertilizers for plant production and removal of pollutants before use in e.g. building materials or in road fillings.

Trials on growing wheat on a fertilizer made of wood ash and meat&bone meal have been conducted, with positive results. The results was presented at an international conference in Austria, and submitted as a book-article. There has also been collaboration with the Norwegian Food Agency about approving such a fertilizer within the frame of the national fertilizer regulations.

4.2 SP2 Conversion mechanisms

The research tasks in this subproject are related to feedstock requirements and technology implications for efficient use of new bioenergy fractions and mixtures.

Main focus is on the fundamental mechanisms for production of biogas and heat and power from biomass, organic waste and municipal solid waste. This includes the mechanisms involved in combustion (WP2.1), gasification (WP2.2), pyrolysis (WP2.3) and anaerobic digestion (WP2.4). The key issues connected to these fundamental mechanisms are efficiencies with respect to energy yields, costs and raw materials utilization. Their feedstock implications with respect to fuel quality requirements and their technology implications with respect to emissions, flexibility, and operational reliability and robustness consequences are central.

The work in 2010 has been concentrated on development of the Bioenergy Laboratory in Trondheim as well as on state-of-the-art reports and experimental studies.

4.2.1 WP2.1 Combustion

In 2010 a study on state-of-the art experimental methods for studies of fuel, fuel mixing and additives effects on corrosion, fouling, emissions and residues in combustion processes was finished and presented in a report. This is followed up by an experimental study on additives and fuel mixtures for reduced corrosion and fouling, to be presented in a journal publication in 2011. Additionally, a literature study on the effects of bromated flame retardants in the fuel mix on dioxin and furans formation was started, to be presented in a report in 2011.

In 2010 an experimental study on NOx reduction by staged air combustion was carried out in a multi-fuel reactor, see Figure 4-1, and was submitted to a journal. This will be followed up by a modelling study on NOx reduction by staged combustion in 2012.

Additionally, an experimental study of the influence of pyrolysis oil quality on combustion characteristics and emissions was carried out and presented in a report.

The Bioenergy Laboratory in Trondheim has been completed further with new advanced analysis equipment (purchased/ordered in 2010). This includes:

1. Climate cabinet
2. Climate room
3. Fine laboratory upgrades (ventilation, piping, tables, acid cabinet, H_2O purification unit)
4. Micro-scale
5. Gas cooler
6. Low-range CO/CO_2 analyser
7. Gas and fluid mixing unit
8. Multi-purpose wood stove testing stand upgrades (piping, pumps, regulation valves, flow and velocity measurement, logging capabilities, PM measurement upgrades)
9. High P-T reactor (autoclave) and micro reactor for pyrolysis
10. Biomass shredder (SINTEF Energy Research funds)
11. Pellets press (SINTEF Energy Research funds)

In addition an induction furnace for rapid heat treatment has been acquired by SINTEF Materials and Chemistry as part of the Trondheim part of the CenBio investments funds for 2010.

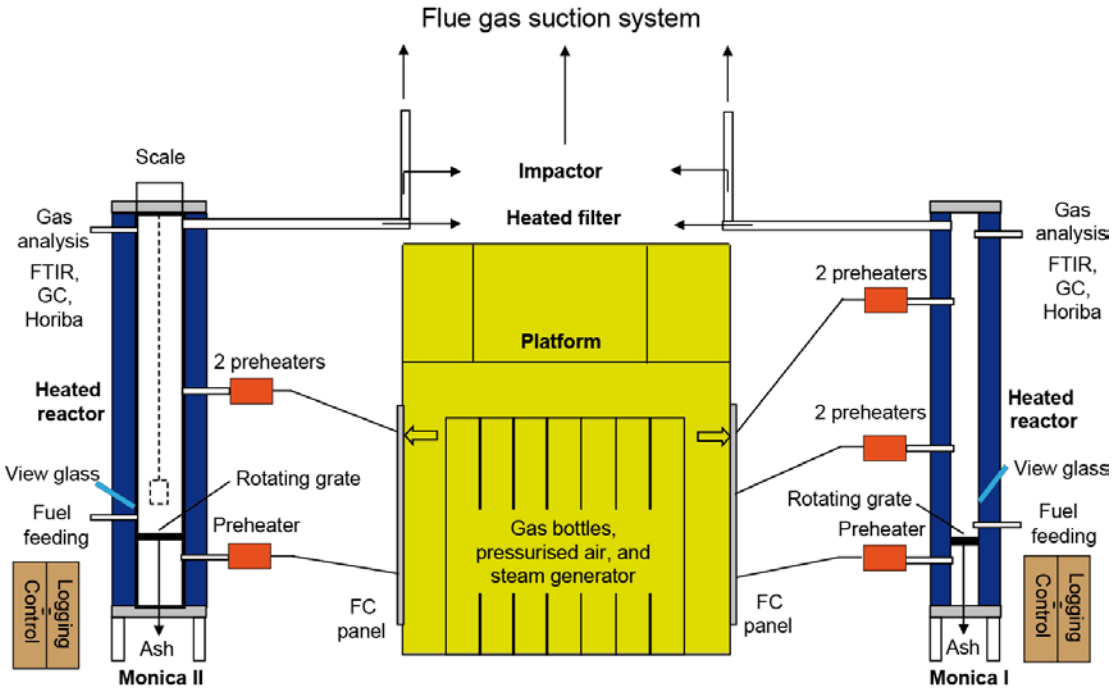

Figure 4-1: Multi-fuel reactor setup.

WP2.1 also includes participating in IEA Task 32, Biomass Combustion and Cofiring.

4.2.2 WP2.2 Gasification

Four technical reports were delivered in this work package in 2010 (D2.2.1-4). D2.2.4 ("Method for determination of devolatilization and char reactivities of biomass and waste particles by fast heating rate TGA") provides the methodological background for further future experimental work. D2.2.3 is a fundamental work in the form of a database cataloguing key fuel properties (especially ash related)

for a variety of biomass fuels and the methods to assess these properties as they are important for understanding reactions, transformations and challenges during conversion processes.
Four deliverables were cancelled due to the long term sick leave of a key researcher. This work was replaced by a new deliverable (see WP2.3).

4.2.3 WP2.3 Pyrolysis

The two 2010 pyrolysis deliverables of this WP are in-depth reviews on modelling and kinetics activities that were used in connection with WP2.2 activities. They clearly exposed the importance of ash-forming compounds in thermal processes. These studies are the basis for further model development, experimental work on biomass reactivity and process concept evaluations.
One deliverable was cancelled due to the long term sick leave of a key researcher.
The cancelled deliverables in WP2.2 and 2.3 were replaced by a journal article presenting experimental results involving Hawaii University, Belgrade University, NTNU and SINTEF-ER. The title of this work is “Is Elevated Pressure Required to Achieve a High Fixed-Carbon Yield of Charcoal from Biomass? 1. Round Robin Results for Three Different Corncob Materials.” And even though it is a laboratory work, it offers important insights to the industrial production of charcoal from biomass, a promising product. The manuscript is currently under review by Energy & Fuels, an internationally renowned scientific journal. Similar experiments involving other promising biomass fuels will be carried out in 2011.

4.2.4 WP2.4 Anaerobic Digestion

During 2010 the new biogas laboratory was completed and the first standard operation procedure for biogas potential measurements in feedstocks was established.
A 6 m^3 biogas reactor was put at CenBio’s disposal by Cambi AS (see Figure 4-2). Considerable resources were used for repair and maintenance of the reactor before it eventually was used for production of anaerobic digestate to be used in plant growth studies (field studies).
In 2010 the biogas group demonstrated that biogas yield from willow and straw could by drastically improved when pretreated by steam explosion.
A preliminary review of qualitative aspects of feedstocks has been compiled.

Figure 4-2: The Cambi reactor

4.2.5 KMB STOP: WP2.5 Torrefaction

STOP (STable OPerating conditions in biomass and biomass residues combustion plants) is a competence building project financed by the Research Council of Norway (RCN) and the FME CenBio industry partners, and has an annual budget of 3500 kNOK and runs for 4 years. The annual support from the RCN is 2800 kNOK and from CenBio 700 kNOK. In FME CenBio, STOP is strongly linked to WP2.3 Pyrolysis, WP1.3 Biomass and residue characteristics and quality, WP2.1 Combustion, WP2.2 Gasification, and as well to the WPs of SP3 – Conversion technologies and emissions.

The overall objective of STOP is to establish an internationally oriented Norwegian competence base in the area of biomass torrefaction for stable operating conditions in biomass and biomass residues combustion plants.

The STOP activities are shown in
Figure 4-3.

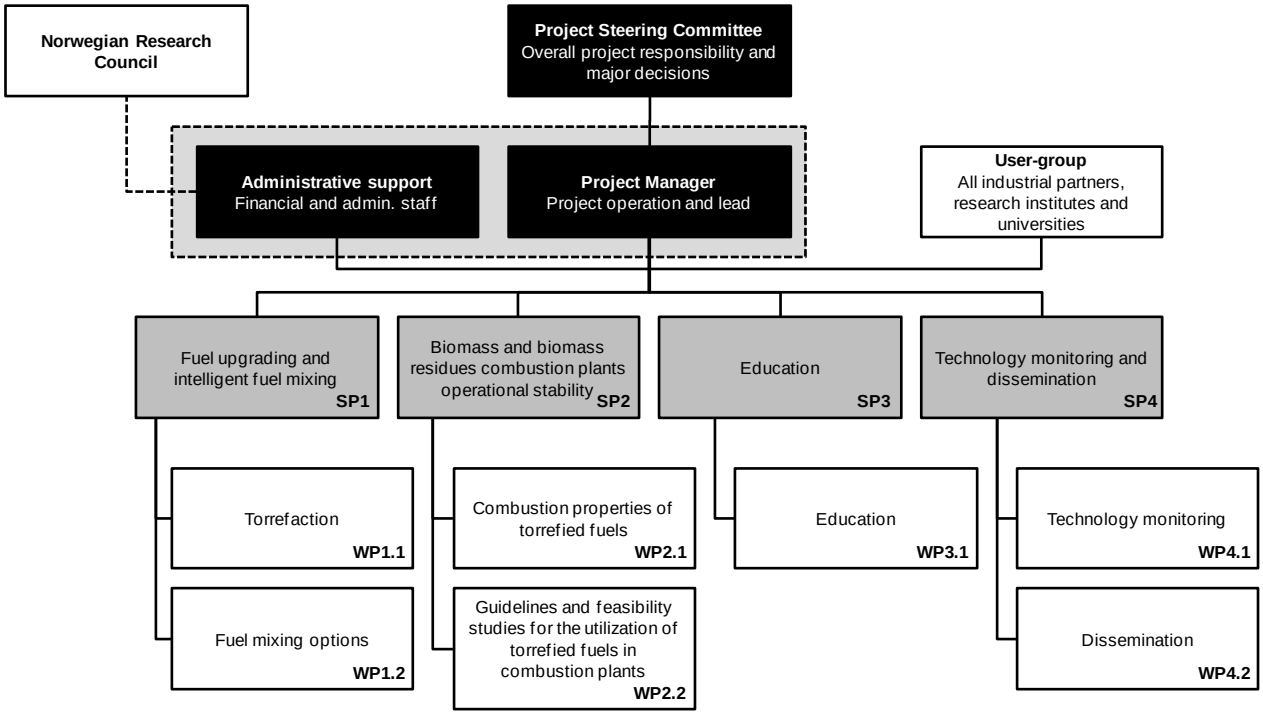

Figure 4-3: STOP activities

Several deliverables are carried out and reported separately in the STOP project, and are available for the CenBio partners in the CenBio eRoom.

4.3 SP3 Conversion technologies and emissions

SP3 objective: To demonstrate that all the energy conversion efficiencies listed in the CenBio Vision 2020 are practically and economically feasible, as well as environmentally benign.

In the Small-scale (stove) segment (WP 3.1) energy efficiencies of 0.85 will be demonstrated for selected fuel fractions, not as peak efficiencies, but as average efficiencies including cold-starts. In the District Heat segment (WP 3.2), efficiencies of 0.9 will be demonstrated, but here the losses in heat distribution are excluded, since heat distribution falls outside the CenBio scope of work. In the Heat and Power segment (WP 3.3) the feasibility of efficiencies of 0.95 will be demonstrated for the combined production of heat and power. In the final Emissions work package (WP 3.4) it will be demonstrated how emissions from plants converting biomass to energy may be reduced to below the half of present regulations.

The activities include:

- Testing methods, for wood stoves
- Reduced emissions and increased efficiency, in wood stoves
- Additives for reduced corrosion and fouling
- Oxygen enriched combustion
- Novel retrofit case studies
- Optimum process integration, cost-efficiency and emission reduction in industrial biomass and MSW heat plants
- Optimum technologies for medium- to large-scale biomass and MSW combustion and gasification CHP plants
- Improved corrosion and emission reduction in CHP boiler by use of additive (ChlorOut)
- Plant emission mapping
- Emission modelling – development of tools, for NOx
- Low emission concept, for NOx

4.3.1 WP3.1 Wood / pellet stoves

A status for standards on wood- and pellet stoves and needed improvements was made in 2009. In 2010 the influence on the emissions due to use of EU standards compared with NS standards was further investigated. Participating in standardization work is a continuous effort in WP3.1. Initial experimental work on transient particle and gas emissions from wood stoves was started in 2009 and more extensive experiments were carried out in 2010.

4.3.2 WP3.2 District heat

The work in this work package explored three very different but equally interesting concepts to improve efficiency during waste incineration: additives against fouling and corrosion, hybrid combined cycles and oxygen enhanced combustion (OEC). OEC will be further studied during an experimental campaign scheduled in 2012; the results will be presented in a journal or conference peer-reviewed article.
WP3.2 also includes participating in IEA Task 36, Integrating Energy Recovery into Solid Waste Management Systems.

4.3.3 WP3.3 Heat and power

A study on possibilities for cost-efficiency improvements in industrial biomass heating plants was started in 2009, and reported in 2010. In 2010 a study on optimum technologies for medium- to large-scale biomass and MSW combustion and gasification CHP plants was started. Installation and start-up of the ChlorOut injection system for combined corrosion prevention and NOx removal at the Jordbro CHP plant in Sweden was started in 2009 and has been ongoing also in 2010. Until March 2011 installation of the ChlorOut injection system will be done.

4.3.4 WP3.4 Emissions

The main objective of the work in WP3.4 Emissions is to develop new recipes for low emission plants. A literature survey on NOx precursors release and available models was started in 2009, and was reported in 2010. In 2010 a literature survey on NOx reduction measures in WtE and BtE plants was started. An initial work connected to a planned continuous effort on mapping of emissions from Biomass to Energy (BtE) plants and Waste to Energy (WtE) plants was started in 2009, and was reported in 2010. In this work a questionnaire needed to collect available data from the partners was developed in cooperation with the partners. Based on this, available data from the partners was collected and the need for new measurements identified. This work will be followed up, leading to an extensive and well planned experimental campaign at a selected plant in 2011.

4.4 SP4 Sustainability analysis

This SP has as main objectives to perform sustainability analyses of the main bioenergy technologies investigated/developed in SP1, SP2 and SP3, based on the three pillars for sustainability: environmental, social and economic factors.

4.4.1 WP4.1 Extended Life Cycle Assessment

The research activities for 2010 are performed in line with the research plan. A stronger focus has been needed on modelling in particular climate impact from bioenergy than foreseen in the plan, which has required some reprioritising of research activities. Some major achievements in 2010 has been on reviewing the state-of-the art, developing a new model for assessment of CO2 from biogenic sources, and performed a set of case studies, e.g. on biorefineries and CHP systems.

4.4.2 WP4.2 Ecosystem management

In May 2010 we planted Norway spruce on all sub-plots at the Gaupen experimental site in Ringsaker municipality. We will follow their development, especially whether they develop differently due to the presence or absence of slash. Studies of twig and needle decomposition on the forest floor show that there is about 70% of the twig mass and 60% of the needle mass left after one year.

A PhD student, funded by CenBio and UMB, started in December 2009. She is working on modelling of data from long-term whole-tree thinning experiments.

Preliminary results from the long-term experiments were presented at a meeting at Kamloops, Canada in June 2010 and other results from the project were presented at a meeting near Riga, Latvia, in March 2010 (Deliverable 4.2.2).

Deliverable 4.2.3, a paper on the effect of harvesting type on soil water chemistry, was delayed because of instrument malfunction. This deliverable will be completed in 2011.

4.4.3 WP4.3 Costs, markets, policies and integrated sustainability analyses

In 2010 work was started on improving the NTM II and EFI-GTM models and applying them for analyses of national and international timber supply issues – in particular impacts on the competition for wood biomass in Norway of increased bioenergy prices, analyses of effects and costs of selected policies to increase bioenergy use and reduce GHG emissions from heating in Norway, and the

international timber supply/demand impacts of increased Russian export tariffs and regulations of illegal logging. The WP leader participated in one meeting in the project EU-Bionet and in two meetings in the IEA Task 40 (International trade of biomass). WP4.3 has finances for only one research position, and we were able of recruiting a senior researcher (Dr. A. Moiseyev) who will start working in CenBio medio April 2010, but could participate in some of the above mentioned works in 2009. Most of the work in 2010 in WP4.3 has therefore been done in collaboration with other projects and by using permanent employed persons at UMB/INA.

4.5 SP5 Knowledge Transfer and Innovation

Important milestones are met in SP5 during 2010. The graduate school has contributed to establishing a master course in bioenergy at UMB and NTNU, a series of publications and media contributions are worked out, and the first plan for innovations is established.

4.5.1 WP5.1 Bio-Energy Graduate School

The maybe most important activity in 2010 was to establish a joint master level course in bioenergy at UMB and NTNU. In addition, a database over PhD students are established at the first workshop for the PhD students was arranged in 2010. The graduate school also provides information on relevant activities and courses at PhD level.

4.5.2 WP5.2 Knowledge transfer and dissemination

Akerhus Energy launched their "Energy Park" in Lillestrøm in 2010, a district heating plant based on energy from wood chips, biooil, sun heat, landfill biogass and heat exchangers in wastewater pipes. The plant has been designed for R&D projects in parallel to normal operation, and several master thesis have been proposed. The company also started constructing separate facilities for researchers and students, to be completed in spring 2011.

The second CenBio day (January 2011) was planned during 2010 as an international conference, involving highly ranked keynote speakers. Important findings from CenBio and the international bioenergy research was on the agenda.

CenBio researchers have been active players in public discussions during 2010, with 20 articles in Norwegian newspapers, thematic journals and forskning.no. The main subject was discussions about the sustainability of forest based bioenergy.

Production of scientific journal papers has been prioritized in 2010: 5 papers published, 1 accepted and 3 submitted, in total 9.

4.5.3 WP5.3 Innovation Management

In order to develop a common perspective on the expected role of Innovation in CenBio, to put innovation on the agenda and to nurture innovation work several activities have been carried out in 2010.

The first innovation workshop in CenBio was arranged in Trondheim 17 November 2010. The main objective of the workshop was to put innovation on the agenda in CenBio. Topics that were

discussed in group sessions during the workshop included: How to define innovation in CenBio, How to work with innovation in CenBio, status of innovation work and potential innovations. A list of identified potential innovations and their status and further plans was established. Follow up the work and status of the identified potential innovations will be important in the next years.

The discussions during the innovation workshop provided input to the first version of the CenBio Innovation Plan (D5.3.1). This document describes the first version of the CenBio innovation plan, which is one important step in this work. Three primary mechanisms are emphasized; (1) arenas for communication, (2) will to innovate, and (3) systems and assistance. Several specific activities and actions were pointed out.

CenBio has in 2010 introduced the “Bioenergy Innovation Award” (BIA), a national innovation award within stationary bioenergy. Criteria for the Bioenergy Innovation Award (BIA) were developed, and a committee was established to evaluate candidates nominated for the Bioenergy Innovation Award and appoint the winner. The Bioenergy Innovation Award was announced nationally, and it will be awarded 17 January 2011 during the CenBio days.

5 INTERNATIONAL COOPERATION

5.1 EU co-funded projects

5.1.1 NextGenBioWaste

NextGenBioWaste is a four year EU co-funded project that started in February 2006. The full title "Innovative demonstrations for the next generation of biomass and waste combustion plants for energy recovery and renewable electricity production" indicates the main issues addressed in the project. In addition to the technical achievements obtained during the four year cooperation the networking aspect was of great value.

SINTEF Energi AS was the Coordinator of the project with 17 partners from seven European countries as illustrated in Figure 5-1.

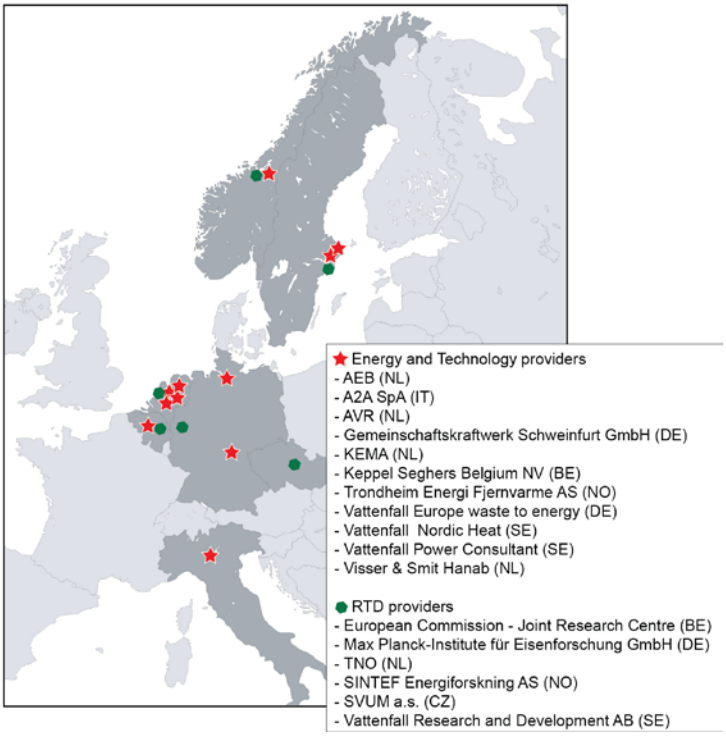

Figure 5-1: Partners in NextGenBioWaste

5.2 International organisations

In Table 5-1 the various tasks within IEA Bioenergy where CenBio personnel are involved are listed.

Table 5-1: Participation in IEA Bioenergy activities

IEA Bioenergy Task No	Task title	Task member WP No	Representative
Task 32	Biomass Combustion and Co-firing	02 SINTEF-ER WP2.1	Øyvind Skreiberg
Task 33	Thermal Gasification of Biomass	02 SINTEF-ER WP2.2	Rainer Backman
Task 36	Integrating Energy Recovery into Solid Waste Management Systems	02 SINTEF-ER WP3.2	Michaël Becidan
Task 37	Energy from biogas and landfill gas	04 BIOFORSK WP2.4	Espen Govasmark
Task 38	Greenhouse gas balances of biomass and bioenergy systems	01 UMB+03 NTNU	Anders Strømman
Task 40	Sustainable International Bioenergy Trade - Securing Supply and Demand	01 UMB WP4.3	Birger Solberg Erik Trømborg

5.3 International institutions

The institutions listed below were involved during the application phase of CenBio in 2008. During the second year of operation there has been some contact on an individual basis with personnel from some of these institutions..

- Stanford University (USA)
- US Forest Service
- University of Minnesota (USA)
- Finnish Forest Research Institute
- Chalmers University of Technology (S)
- Abo Akademi University (SF)
- Technical University of Denmark
- University of Copenhagen (DK)
- Vienna University of Technology (A)
- Technical University Bergakademie Freiberg (D)

Lars Sørum visited University of California Berkley and Stanford University, 18-23 October 2010 to follow up LoIs to CenBio.

Birger Solberg visited US Forest Service, Atlanta, November 2010 to follow up their LoI to CenBio.

5.4 International conferences

CenBio has been presented at some international conferences in 2010.

Trond Knapp Haraldsen presented "Mixtures of bottom wood ash and meat and bone meal as NPK fertilizer" at the conference on Recycling of Biomass Ashes, Innsbruck, Austria, 22 March 2010.

Odd Jarle Skjelhaugen and Per Arne Karlsen (Akershus Energi) gave a presentation at NEREC 2010 (North European Renewable Energy Convention), 28-29 September 2010, Lillestrøm. The title was "CenBio - Bioenergy Innovation Centre, Visions, value potential and recent research results".

Odd Jarle Skjelhaugen attended the Transatlantic Science Week, Washington, 18-20 October 2010.

Odd Jarle Skjelhaugen visited University of Minnesota 20-23 October 2010 to follow up UMNs LoI to CenBio. There was a dialog with 6 researchers about collaborative actions within sustainability and anaerobic treatment.

Several CenBio staff gave presentations to and had chair tasks at the international Renewable Energy Research Conference, Trondheim 7-8 June 2010, and at SETAC Europe 20th annual meeting – Science and technology for environmental protection, Seville, Spain 23-27 May 2010. In addition, presentations were given at the Environmental Impacts of Increased Bioenergy Use conference, Riga, Latvia 16-18 March 2010; at the European Biomass Conference, Lyon, France 2-7 May 2010; and at the 7th Biennial Workshop on Advances on Energy Studies, Barcelona, Spain, 18-22 October 2010. More details about titles and presenters can be found under section 8.3.3 Conference Presentations.

6 DISSEMINATION

6.1 Website

The first version of the CenBio website was established and published in June 2009. Figure 6-1 shows the front page.

Figure 6-1: CenBio website

6.2 Deliverables

All results from both management and research activities within CenBio are documented in Deliverables, whether they are public or for internal distribution only. The list presented in Table 8-13 shows the deliverables that were finalised in 2010.

The deliverables are numbered according to the WP to which it belongs with the third digit as a unique counter. One deliverable in a series of several planned deliverables is marked with a new counter as the fourth digit. The number for this report illustrates the numbering system: D0.1.4_2 where 0.1 refers to WP0.1, 4 is selected as the unique number for annual reports while the _2 means the second in a series; i.e. annual report for the second year of operation.

7 ACCOUNTS

A detailed accounts report for 2010 was submitted to RCN in January 2011. The main financial figures are repeated in this annual report.

7.1 Budget

Table 7-1 shows the anticipated overall budget for CenBio for eight years, as presented in the AWP2010. The total costs are estimated at NOK 271,680 million, distributed as given in the table.

The total funding from RCN is NOK 120 million for all four years, i.e. NOK 15 million per year. Since CenBio started 1 March 2009 the budget for 2009 was somewhat reduced compared to an average year. The cost budget for 2010 was NOK 33,960 million while the estimate before final reporting for 2010 was NOK 34,000 million. The budgeted funding from RCN was NOK 15,000 million.

Table 7-1: CenBio overall budget (source: CenBio Annual Work Plan 2011)

		Actual	Estimate	Budget	Plan					
mill. NOK	**Total**	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total	**271,680**	**27,738**	**34,000**	**34,028**	**33,950**	**33,950**	**33,950**	**33,950**	**33,950**	**6,164**

7.2 Accounts 2010

Total costs reported from the partners in 2010 amounts to NOK 38,6 million, of which NOK 30,7 million from Research partners and NOK 7,8 million from Industry partners. The funding from RCN amounts to 39% of the total costs.

8 APPENDICES

8.1 Personnel

8.1.1 Key researchers

Table 8-1: Key researchers

Name	Sex	Affiliation	Topic/Research area	Funding	Duration
Odd Jarle Skjelhaugen	M	01 UMB	Coordination	CenBio	
Tron Eid	M	01 UMB	Feedstock supply	CenBio	
Øivind Løken	M	01 UMB	Feedstock supply	CenBio	
Hans Fredrik Hoen	M	01 UMB	Biomass supply and residue utilization	CenBio	
Olav Høibø	M	01 UMB	Biomass and residue characteristics	CenBio	
Birger Solberg	M	01 UMB	Sustainability analysis	CenBio	
Vincent Eijsink	M	01 UMB	Pretreatment & biogas	CenBio	
Svein Jarle Horn	M	01 UMB	Pretreatment & biogas	CenBio	
Lars Sørum	M	02 SINTEF-ER	Coordination	CenBio	
Einar Jordanger	M	02 SINTEF-ER	Coordination	CenBio	
Øyvind Skreiberg	M	02 SINTEF-ER	Conversion technologies	CenBio	
Rainer Backman	M	02 SINTEF-ER	Conversion mechanisms	CenBio	
Michael Becidan	M	02 SINTEF-ER	District heat	CenBio	
Edvard Karlsvik	M	02 SINTEF-ER	Wood- and pellet stoves	CenBio	
Roger Khalil	M	02 SINTEF-ER	Biomass and residue characteristics	CenBio	
Judit Sandquist	F	02 SINTEF-ER	Biomass and residue characteristics	CenBio	
Franziska Goile	F	02 SINTEF-ER	Conversion technologies	CenBio	
Bjarne Malvik	M	02 SINTEF-ER	Conversion technologies	CenBio	
Mette Bugge	F	02 SINTEF-ER	Innovation Management	CenBio	
Anders Strømman	M	03 NTNU	Knowledge Transfer and Innovation	CenBio	
Ottar Michelsen	M	03 NTNU	Bio-Energy Graduate School	CenBio	
Trond Haraldsen	M	04 BIOFORSK	Residues upgrading and use	CenBio	
Roald Sørheim	M	04 BIOFORSK	Anaerobic Digestion	CenBio	
Tormod Briseid	M	04 BIOFORSK	Anaerobic Digestion	CenBio	
Roar Linjordet	M	04 BIOFORSK	Anaerobic Digestion	CenBio	
Mie Bjune	F	04 BIOFORSK	Anaerobic Digestion	CenBio	
Bruce Talbot	M	05 NFLI	Logistics	CenBio	
Anders Eid Hohle	M	05 NFLI	Biomass supply and residue utilization	CenBio	
Simen Gjølsjø	M	05 NFLI	Biomass supply and residue utilization	CenBio	
Kjell Vadla	M	05 NFLI	Biomass supply and residue utilization	CenBio	
Rasmus Astrup	M	05 NFLI	Biomass supply and residue utilization	CenBio	
Aron Smith	M	05 NFLI	Biomass supply and residue utilization	CenBio	
Nicolas Clarke	M	05 NFLI	Ecosystem management	CenBio	
Geir Østreng	M	05 NFLI	Ecosystem management	CenBio	
Bjarte Arne Øye	M	06 SINTEF-MC	Residues upgrading and use	CenBio	
Lennart Gårdman	M	07 VRD	Heat and power	CenBio	

8.1.2 Postdoctoral researchers

Table 8-2: Postdoctoral researchers

Name	Sex	Affiliation	Topic/Research area	Funding	Duration
Francesco Cherubini	M	03 NTNU	LCA bioenergy systems	CenBio	2009-10 2011-09
Edita Garskaite	F	01 UMB	Pyrolysis and solar cells	UMB	2010 2012
Marit Lie	F	01 UMB	Bio diversity forest and sustainability	UMB	2010 2012
Bjørge Westereng	M	01 UMB	Enzym processes	UMB	2010 2012
Zehra Zengin		01 UMB	Biogas	UMB	2010 2012

8.1.3 PhD students

A database on PhD students working on issues in relation to CenBio is established, see Table 8-3.

Table 8-3: PhD students, CenBio funded and associated (updated December 2010)

Name	Sex	Affiliation	Topic/Research area	Funding	Duration
Paulo Borges	M	01 UMB	Develop decision support systems for long-term analyses of biomass	CenBio WP1.1	2010-11 2013-11
Aron Smith	M	05 NFLI	Develop models and methods for quantification of birch biomass	CenBio WP1.1/ NFR	2010-08 2013-08
Geoffrey Guest	M	03 NTNU	Hybrid life cycle analysis of solid bio-fuel systems	CenBio WP4.1	2009-08 2012-09
Shaza Ayoub	F	01 UMB / Comsats			2007-10
Ryan Bright	M	03 NTNU	LCA of Second Generation Biofuels		2008-09 2011-11
Shuling Chen		01 UMB	Bioenergimarkeder		
Maria M. Estevez	F	01 UMB	Optimization of biogas production (From biomass to biogas project)		2009-12 2012-11
Kristian Fjørtoft	M	01 UMB	Biogas optimization in farm scale biogas plants		2009-08
Zarah Forsberg	F	01 UMB	Characterization and directed evolution of carbohydrate-binding modules (CBMs) for biomass conversion		2010-01 2013-12
Espen Halvorsen	M	01 UMB	Matrix based decision support system for forest management ms	UMB	2008-11 2011-11
Per-Ivar Hanedalen	M	01 UMB	Life cycle assessment of bio energy based on raw materials from agricultural systems	UMB	2009-09 2013-01
Knut Marius Hauglin	M	01 UMB	Estimating forest biomass components using airborne laser scanning	UMB+ RCN	2008-12 2012
Ehsan Houshfar	M	03 NTNU	Experimental studies on two-stage combustion of biomass	KRAV CenBio In-kind	2009-03 2012-02
Dhandapani Kannan		03 NTNU	Study of Diesel Combustion and Emissions with Fischer-Tropsch (F-T) fuels and Bio fuels		2008-09 2011-09
Dmitry Lysenko	M	03 NTNU	Combustion modeling	CenBio In-kind WP2.1	2010-03 2014-03

Name	Sex	Affiliation	Topic/Research area	Funding	Duration
Heidi Nygård	F	01 UMB	Pyrolysis of Biomass in Molten Salts		2009-06 2013-06
Kavitha Pathmanathan	F	03 NTNU	High Temperature Filtration of biomass combustion and gasification processes		2007-06 2011-06
Hanne K. Sjølie	F	01 UMB	Economic analyses of use of forest and wood products in Norway to reduce the atmospheric concentration of greenhouse gases (GHG)	UMB	2007-11 2011-06
Geir Skjervak	M	03 NTNU / Statoil	High Temperature Filtration of biomass combustion and gasification processes		
Silje Skår	F	01 UMB	Ecological modelling related to increased biomass removal in forests in Norway		2009-12 2013-12
Dhruv Tapasvi	M	03 NTNU	Experimental studies on biomass torrefaction and gasification	CenBio WP2.3	2010
Clara Valente	F	01 UMB / HiHm	Impacts of woody biomass production for bioenergy purpose in mountainous areas: studies from Norway and Italy	RCN	2008-09 2011-11
Liang Wang	M	03 NTNU	Biomass gasification	CenBio In-kind	2006-09 2010-06
Hong Zhai		01 UMB			2008-08 2011-07

8.2 Accounts

8.2.1 Funding

Table 8-4: Funding

Source	NOK million
The Research Council	15,000
Research partners	10,462
Industry partners	13,132
Public partners	0,000
Total	**38,594**

8.2.2 Costs

Table 8-5: Costs

Source	NOK million
Research partners	30,445
Industry partners	7,833
Public partners	0,000
Equipment	0,316
Total	**38,594**

8.3 Publications

All types of publications produced within CenBio are listed in Table 8-13. Below some specific publications are listed in separate tables.

8.3.1 Journal Papers

Table 8-6: Journal Papers

Title	Author(s)	Journal
Modelling natural drying efficiency in covered and uncovered piles of whole broadleaf trees for energy use	Tore Filbakk, Olav Høibø and Juha Nurmi	Biomass and Bioenergy
Multi-fuel reactor experiments with staged air combustion for NOx emission reduction	Ehsan Houshfar, Øyvind Skreiberg, Terese Løvås, Dušan Todorović and Lars Sørum	Fuel (consideration for publication)
Life cycle assessment of bioenergy systems: State of the art and future challenges	Francesco Cherubini and Anders H. Strømman	Bioresource Technology
Life Cycle Assessment of Biomass-based Combined Heat and Power Plants: Centralized versus Decentralized Deployment Strategies	Geoffrey Guest, Ryan M. Bright, Francesco Cherubini, Ottar Michelsen and Anders H. Strømman	Journal of Industrial Ecology
The environmental impacts of biorefinery products: influence of allocation methods on final	Francesco Cherubini, Anders H Strømman and Sergio Ulgiati.	Resources, Conservation & Recycling
Production of Biofuels and Biochemicals from Lignocellulosic Biomass: Estimation of Maximum Theoretical Yields and Efficiencies Using Matrix Algebra	Francesco Cherubini and Anders H. Strømman	Energy Fuels
CO_2 emissions from biomass combustion for bioenergy: atmospheric decay and contribution to global warming	Francesco Cherubini, Glen P. Peters, Terje K. Berntsen, Anders H Strømman, Edgar Hertwich	GCB Bioenergy
Forest sector impacts of the increased use of wood in energy production in Norway	Erik Trømborg and Birger Solberg	Forest Policy and Economics
Effects and costs of policies to increase bioenergy use and reduce GHG emissions from heating in Norway	Hanne K. Sjølie, Erik Trømborg, Birger Solberg, Torjus F. Bolkesjø	Forest Policy and Economics
Forest sector market impacts of changed roundwood export tariffs and investment climate in Russia	Birger Solberg, Alexander Moiseyev, A. Maarit I. Kallio and Anne Toppinen	Forest Policy and Economics

8.3.2 Published Conference Papers (including extended abstracts and posters)

Table 8-7: Publishes Conference Papers

Title	Author(s)	Conference
Application of LCA methodology to bioenergy systems - A review	Francesco Cherubini, Ottar Michelsen, Anders Hammer Strømman	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010
LCA of biofuelled combined heat and power plants - centralized versus decentralized deployment strategies	Geoffrey Guest; Ryan M. Bright; Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010

LCA of biorefinery systems: environmental impacts, biogenic C flows, allocation issues and biodiversity implications of a Norwegian wood based concept	Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	European Biomass Conference in Lyon, France, 2-7 May 2010
Efficient use of biomass for greenhouse gas mitigation	Ottar Michelsen; Francesco Cherubini; Ryan M. Bright; Geoffrey Guest; Anders Hammer Strømman	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010
Challenges in life cycle assessment of forestry activities with a focus on land use impact	Ottar Michelsen; Francesco Cherubini; Anders Hammer Strømman	LCANZ and NZLCM Centre conference "Life cycle assessment and footprinting – Bridging the gap between tools and practice" in Wellington, New Zealand, 24-25 March 2010.

8.3.3 Conference Presentations

Table 8-8: Conference Presentations

Title	Author(s)	Conference
Variations in Norwegian biomass, a literature study	Judit Sandquist	Renewable Energy Research Conference in Trondheim 7-8 June 2010
Application of LCA methodology to bioenergy systems - A review	Francesco Cherubini, Ottar Michelsen, Anders Hammer Strømman,	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010
LCA of biofuelled combined heat and power plants - centralized versus decentralized deployment strategies	Geoffrey Guest; Ryan M. Bright; Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010
LCA of biorefinery systems: environmental impacts, biogenic C flows, allocation issues and biodiversity implications of a Norwegian wood based concept	Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	European Biomass Conference in Lyon, France, 2-7 May 2010
Efficient use of biomass for greenhouse gas mitigation	Ottar Michelsen; Francesco Cherubini; Ryan M. Bright; Geoffrey Guest; Anders Hammer Strømman	SETAC Europe 20th annual meeting - Science and technology for environmental protection; Seville, Spain, 23-27 May 2010
Life cycle Assessment of bio-fuelled combined heat and power plants - centralized versus decentralized deployment strategies	Geoffrey Guest; Ryan M. Bright; Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	Renewable Energy Research Conference in Trondheim 7-8 June 2010
From oil refinery to biorefinery - LCA of a biorefinery system based on Norwegian forest wood	Francesco Cherubini; Ottar Michelsen; Anders Hammer Strømman	Renewable Energy Research Conference in Trondheim 7-8 June 2010
Global warming potential of Bioenergy	Francesco Cherubini	7th Biennial Workshop on Advances on Energy Studies, Barcelona, Spain, 18-22 October 2010
Ecological effects of increased biomass removal for bioenergy: a summary of Norwegian research	Nicholas Clarke	Environmental Impacts of Increased Bioenergy Use, Riga, Latvia on 16-18 March 2010
A review on torrefaction of biomass	Dhruv Tapasvi	Renewable Energy Research Conference in Trondheim 7-8 June 2010

Title	Author(s)	Conference
Status for standards on wood- and pellet stoves and needed improvements	Edvard Karlsvik	Renewable Energy Research Conference in Trondheim 7-8 June 2010
Review of Additives Used for Abating Ash Related Problems in Biomass Combustion	Liang Wang	Renewable Energy Research Conference in Trondheim 7-8 June 2010
Emission Control through Primary Measures in Biomass Combustion	Eshan Houhsfar	Renewable Energy Research Conference in Trondheim 7-8 June 2010

8.3.4 Books/Chapter in books

Table 8-9: Chapter in books

Book title	Chapter title	Author(s)
Springer Verlag	Mixtures of bottom wood ash and meat and bone meal as NPK fertilizer	Trond Knapp Haraldsen, Per Anker Pedersen and Arne Grønlund

8.3.5 Reports

Table 8-10: Reports

Title	Classification	Author(s)
Estimation, availability and production of tree biomass resources for energy purposes - research challenges in Norway	Public	Tron Eid, Andreas Brunner, Gunnhild Søgaard, Rasmus Astrup, Stein Tomter, Øivind Løken and Rune Eriksen
Residues upgrading and use: Literature study-characterisation and use of biofuel ashes	Restricted	Bjarte Øye
State-of-the art experimental methods for studies of fuel, fuel mixing and additives effects on corrosion, fouling, emissions and residues in combustion processes	Restricted	Liang Wang
Report from pyrolysis oil combustion experiments	Restricted	Liang Wang
Bioenergy laboratory development 2010	Restricted	Øyvind Skreiberg
State-of-the-art review on influence of fuel and process conditions on gas yield and quality in biomass gasification processes	Restricted	Liang Wang
Report on state-of-the-art of biomass gasification modeling	Restricted	Berta Matas Güell
Technology related quantities to consider in fuel property database	Restricted	Liang Wang
Method for determination of devolatilization and char reactivities of biomass and waste particles by fast heating rate TGA	Restricted	Liang Wang
Report on state-of-the-art of biomass pyrolysis modeling	Restricted	Liang Wang
Influence of ash components on devolatilisation kinetics of biomass particles	Restricted	Liang Wang
Kunnskapsstatus og forskningsbehov	Restricted	Roald Sørheim, Tormod Briseid, Trond Knapp Haraldsen, Roar Linjordet, Bernd Wittgens, Øivind Hagen, Kjell D. Josefsen, Svein Jarle Horn, John Morken, Jon Fredrik Hanssen, Anders Lunnan, Helge Berglann and Knut Krokann
6 m3 anaerobic digester operating at Ås	Restricted	Roald Aasen
The influence on the emissions due to use of EU standards compared with NS standards	Restricted	Franziska Goile

Title	Classification	Author(s)
Literature review on additives against fouling and corrosion	Public	Michael Becidan
Retrofit possibilities for increased electric efficiency	Restricted	Michael Becidan
OEC review and initial experiments	Restricted	Roger Khalil
Possibilities for cost-efficiency improvements in industrial biomass heating plants	Restricted	Edvard Karlsvik
Mapping of emissions from BtEand WtE plants - Initial work	Restricted	Mette Bugge
Literature survey on NOx precursors release and available models	Restricted	Øyvind Skreiberg
Wood based products in Norway – Flows and Life Cycle Inventories	Public	Magnus Grinde

8.4 List of partners – short names

For the sake of convenience unique short names for all partners have been defined. These can be found in Table 8-11.

Table 8-11: Short names of partners

No	Short name	Entity legal name
01	UMB	Universitetet for miljø- og biovitenskap (Host institution)
02	SINTEF-ER	SINTEF Energi AS (Coordinating institution)
03	NTNU	Norges teknisk-naturvitenskapelige universitet NTNU
04	BIOFORSK	Bioforsk
05	NFLI	Norsk institutt for skog og landskap
06	SINTEF-MC	Stiftelsen SINTEF
07	VRD	Vattenfall Research and Development AB
08	AKERSHUS	Akershus Energi AS
09	SKOGEIER	Norges Skogeierforbund
10	AGDER	Agder Energi AS
11	NTE	NTE Holding AS
12	HAFSLUND	Hafslund ASA
13	STATKRAFT	Trondheim Energi Fjernvarme AS
14	NSKOG	Norske Skogindustrier ASA
15	XYNERGO	Xynergo AS
16	PROTEIN	Norsk Protein AS
17	AVFALLN	Avfall Norge
18	BONDELAG	Norges Bondelag
19	EGE	Oslo Kommune Energigjenvinningsetaten
20	AEB	Afval Energie Bedrijft
21	VHN	Vattenfall AB, Heat Nordic
22	ENERGOS	Energos AS
23	CAMBI	Cambi AS
24	JØTUL	Jøtul AS
25	BIONORDIC	BioNordic AS
26	GKAS	Granit Kleber AS

8.5 Deliverables list – Publications

AWP2010 included a total of 107 deliverables. Of these, 96 were planned to be finalised in 2010; two were finalised already in 2009, and 9 were planned to be finalized in 2011.

During 2010, 15 new deliverables were added to the original Deliverables list. The total number of deliverables in Table 8-12 below is therefore 122, with 111 deliverables due in 2010.

During the year, 8 of the original deliverables were cancelled. In addition, 19 deliverables were delayed for various reasons, as explained in section 4. Almost all delays and cancellations can be explained by the following four categories: (1) delayed employments, (2) breakdown of instruments, (3) delayed deliveries, and (4) sick leaves.

In total, 84 deliverables were finalised in 2010.

Table 8-13: List of Deliverables 2010

Del. No	Deliverables title	Lead partner	Dated
D0.1.1_2	Annual Work Plan 2010	SINTEF-ER	2009-12-22
D0.1.1_3	Annual Work Plan 2011	SINTEF-ER	2010-12-30
D0.1.2_21	Progress report 1 2010	SINTEF-ER	2010-06-01
D0.1.2_22	Progress report 2 2010	SINTEF-ER	2010-12-06
D0.1.3_1	Accounts report 2009	SINTEF-ER	2010-03-14
D0.1.3_2	Accounts report 2010	SINTEF-ER	2011-02-04
D0.1.4_1	Annual report 2009	SINTEF-ER	2010-04-16
D1.1.1	Estimation, availability and production of tree biomass resources for energy purposes -research challenges in Norway	UMB	2010-11-01
D1.1.2	Current biomass availability in Norway	NFLI	Delayed
D1.1.3	Current biomass availability in Norway (pop science article)	NFLI	2010-12-31
D1.1.4	Potential future biomass availability in Norway	UMB	Delayed
D1.1.5	PhD employment (NLFI based) related to birch biomass	NFLI	2010-09-30
D1.1.6	PhD employment (UMB based)	UMB	2010-06-30
D1.1.7	Potential future biomass availability in Norway (pop science article)	UMB	Delayed
D1.2.1	Road Map: Defining the goals, roles and procedure for WP1.2	NFLI	Delayed
D1.2.2	Initial status report on unit costs and productivity estimates of relevant forest operation elements	NFLI	Delayed
D1.2.3	Technical survey report: an overview of biomass production and delivery systems in a Norwegian context	NFLI	Delayed
D1.3.1	Variations in Norwegian biomass, a literature study to be presented at CenBio conference	SINTEF-ER	2010-06-07
D1.3.2	Modelling natural drying efficiency in covered and uncovered piles of whole broadleaf trees for energy use	NFLI	2010-10-28
D1.3.3	Data about selected waste fractions characteristics : systematisation and analysis	SINTEF-ER	2010-12-07
D1.3.4	Influence of contaminants in biomass combustion	SINTEF-ER	Delayed
D1.4.1	Residues upgrading and use: Literature study-characterisation and use of biofuel ashes	BIOFORSK	2010-02-02
D1.4.2	Results from two green house experiments with ash based products (experiments carried out in 2010 and 2011)	BIOFORSK	Delayed
D1.4.3	Mixtures of bottom wood ash and meat and bone meal as NPK fertilizer	BIOFORSK	2010-10-18
D2.1.1	State-of-the art experimental methods for studies of fuel, fuel mixing and additives effects on corrosion, fouling, emissions and residues in combustion processes	SINTEF-ER	2010-09-16
D2.1.2	Multi-fuel reactor experiments with staged air combustion for NOx emission reduction	SINTEF-ER	2010-12-14
D2.1.3	Report from pyrolysis oil combustion experiments	SINTEF-ER	2010-12-29
D2.1.5	Bioenergy laboratory development 2010	SINTEF-ER	2010-12-30
D2.1.6	Additives and fuel mixes for reduced corrosion and fouling - Experimental study	SINTEF-ER	Jun-11
D2.1.7	The effects of bromated flame retardants in the fuel mix on dioxin and furans formation - Literature study	SINTEF-ER	Delayed
D2.1.8	NOx emission reduction by staged combustion - modelling study	SINTEF-ER	Jun-12
D2.1.10	IEA Task 32 activity report	SINTEF-ER	2/year
D2.2.1	State-of-the-art review on influence of fuel and process conditions on gas yield and quality in biomass gasification processes	SINTEF-ER	2010-12-29
D2.2.2	Report on state-of-the-art of biomass gasification modeling	SINTEF-ER	2010-12-03
D2.2.3	Technology related quantities to consider in fuel property database	SINTEF-ER	2010-11-11
D2.2.4	Method for determination of devolatilization and char reactivities of biomass and waste particles by fast heating rate TGA	SINTEF-ER	2010-10-18
D2.2.5	Results from reactivity measurements of 4-6 fuels	SINTEF-ER	Cancelled

Del. No	Deliverables title	Lead partner	Dated
D2.2.6	Description of software and platform to use in model development	SINTEF-ER	Cancelled
D2.2.7	Detailed description and results of process model for gasification	SINTEF-ER	Cancelled
D2.2.8	Parametric study and model simulation for 2-3 different combinations of process concepts and fuels	SINTEF-ER	Cancelled
D2.2.9	IEA Task 33 activity report	SINTEF-ER	2/year
D2.3.1	Report on state-of-the-art of biomass pyrolysis modeling	SINTEF-ER	2010-06-18
D2.3.2	Influence of ash components on devolatilisation kinetics of biomass particles	SINTEF-ER	2010-09-23
D2.3.3	Biomass pyrolysis modelling - Particle devolatilisation	SINTEF-ER	Cancelled
D2.3.4	Modelling of high temperature plasma gasification	SINTEF-ER	Delayed
D2.4.1	Common laboratory designated anaerobic digestion at Campus Ås; first SOPs established	BIOFORSK	2010-03-30
D2.4.2	Kunnskapsstatus og forskningsbehov	BIOFORSK	2010-04-10
D2.4.3	Documented overview on relevant raw materials, accessible amount and their characterisitics	UMB	Delayed
D2.4.4-1	First MSc in anaerobic digestion_Co-digestion of cattle manure and food waste	UMB	2009-05-14
D2.4.4-2	Second MSc in anaerobic digestion_Biogas production from dairy cow manure and food waste	BIOFORSK	2009-09-28
D2.4.5	6 m3 anaerobic digester operating at Ås	UMB	2011-03-29
D2.4.6	IEA task 37 "Energy from biogas and landfil gas" Espen Govatsmark, Bioforsk. Minutes.	BIOFORSK	Cont.
D2.4.7	Information flyer and PR	BIOFORSK	Delayed
D3.1.2	Generic experiments on transient particle and gas emissions from wood stoves	SINTEF-ER	2010-12-26
D3.1.3	The influence on the emissions due to use of EU standards compared with NS standards	SINTEF-ER	2010-12-15
D3.1.4	Reports from standardization meetings	SINTEF-ER	x/year
D3.2.1	Literature review on additives against fouling and corrosion	SINTEF-ER	2010-09-14
D3.2.2	Retrofit possibilities for increased electric efficiency	SINTEF-ER	2010-06-07
D3.2.3	OEC review and initial experiments	SINTEF-ER	2010-12-11
D3.2.4	OEC experiments and results	SINTEF-ER	Dec-12
D3.3.1	Possibilities for cost-efficiency improvements in industrial biomass heating plants	SINTEF-ER	2010-09-13
D3.3.2	Installation and start-up of the ChlorOut injection system	VRD	Delayed
D3.3.3	Optimum technologies for medium- to large-scale biomass and MSW combustion and gasification CHP plants	SINTEF-ER	Jun-11
D3.4.1	Mapping of emissions from BtEand WtE plants - Initial work	SINTEF-ER	2010-08-11
D3.4.2	Literature survey on NOx precursors release and available models	SINTEF-ER	2010-08-23
D3.4.3	Emissions from BtE plants - Available data and need for new measurements	SINTEF-ER	Jan-11
D3.4.4	Literature survey on NOx reduction measures in WtE and BtE plants	SINTEF-ER	May-11
D4.1.2	Life cycle assessment of bioenergy systems: State of the art and future challenges	NTNU	2010-02-05
D4.1.3	Application of LCA methodology to bioenergy systems - A review	NTNU	2010-05-24
D4.1.4	LCA of biofuelled combined heat and power plants - centralized versus decentralized deployment strategies	NTNU	2010-12-16
D4.1.5	LCA of biorefinery systems: environmental impacts, biogenic C flows, allocation issues and biodiversity implications of a Norwegian wood based concept	NTNU	2010-05-24
D4.1.6	Life Cycle Assessment of Biomass-based Combined Heat and Power Plants: Centralized versus Decentralized Deployment Strategies	NTNU	2010-10-15
D4.1.7	LCA of biorefinery systems: environmental impacts, biogenic C flows, allocation issues and biodiversity implications of a Norwegian wood based concept	NTNU	2010-05-10

Del. No	Deliverables title	Lead partner	Dated
D4.1.8	LCA of multiple products from a bio refinery	NTNU	Delayed
D4.1.9	The environmental impacts of biorefinery products: influence of allocation methods on final	NTNU	2010-04-26
D4.1.10	Efficient use of biomass for greenhouse gas mitigation	NTNU	2010-05-24
D4.1.11	LCA-based comparisons of alternative uses of biomass	NTNU	Delayed
D4.1.12	Challenges in life cycle assessment of forestry activities with a focus on land use impact	NTNU	2010-03-15
D4.1.13	Test web site established	NTNU	Cancelled
D4.1.14	Production of biofuels and biochemicals from lignocellulosic biomass: estimation of maximum theoretical yields and efficiencies using matrix algebra	NTNU	2010-02-17
D4.1.15	CO_2 emissions from biomass combustion for bioenergy: atmospheric decay and contribution to global warming	NTNU	2010-11-03
D4.1.16	Life cycle Assessment of bio-fuelled combined heat and power plants - centralized versus decentralized deployment strategies	NTNU	2010-06-01
D.4.1.17	From oil refinery to biorefinery - LCA of a biorefinery system based on Norwegian forest wood	NTNU	2010-06-01
D.4.1.18	GWP - Bioenergy presentation	NTNU	2010-10-15
D4.2.2	Ecological effects of increased biomass removal for bioenergy: a summary of Norwegian research	NFLI	2010-03-17
D4.2.3	Manuscript on effects of harvesting type on soil water chemictry	NFLI	Delayed
D4.3.1	Preliminary conceptual report on what is meant by sustainable bioenergy production and discussion of corresponding criteria and indicators	UMB	Delayed
D4.3.2	Evaluation of model changes necessary in EFI-GTM and NTM II for improved bioenergy analyses	UMB	Delayed
D4.3.3	Forest sector impacts of the increased use of wood in energy production in Norway	UMB	2010-09-24
D4.3.4	Effects and costs of policies to increase bioenergy use and reduce GHG emissions from heating in Norway	UMB	2010-09-24
D4.3.5	Forest sector market impacts of changed roundwood export tariffs and investment climate in Russia	UMB	2010-09-24
D4.3.6_21	Participation in EU-Bionet meetings	UMB	2010-01-15
D4.3.6_22	Participation in EU-Bionet meetings	UMB	2010-09-24
D4.3.7	Participation in meeting in IEA Task 40 International trade of biomass	UMB	2010-04-10
D5.1.1	Plan for Bioenergy Graduate School 2010-2012	NTNU	2010-06-15
D5.1.2	Student database - CenBio graduate school	NTNU	Cont.
D5.1.3	1st CenBio graduate school Workshop	NTNU	2010-01-13
D5.1.4	Overview - potential courses at PhD level	NTNU	2010-12-15
D5.1.5	Startup - master course in bioenergy	NTNU	2010-12-15
D5.1.6	2nd CenBio Graduate School Workshop	NTNU	2011-01-21
D5.2.1	Plans for mobility activities between academia and industry	All (SP, WP leaders)	2010-11-02
D5.2.2	CenBio Web site	All (R&D partners)	Cont.
D5.2.3-2	CenBio Innovation Workshop	UMB	2010-11-17
D5.2.3-3	CenBio newsletter No 3	UMB	Cancelled
D5.2.3-4	CenBio newsletter No 4	UMB	Cancelled
D5.2.4	The first annual CenBio conference included GA, EB and PMT-meetings	UMB (and Hafslund)	2010-01-14
D5.2.16	20 popular articles & press news and 10 presentations about CenBio	UMB+All	Cont.
D5.2.5-2	10 scientific articles to be planned	UMB	2010-03-14
D5.2.5-3	10 conference presentations to be planned	UMB	2010-03-14

Del. No	Deliverables title	Lead partner	Dated
D5.2.6	Akershus Energy park	Akershus Energy	2010-11-02
D5.2.7	CenBio 2011 int. conference: start of planning	UMB	2011-01-21
D5.2.8	Presentation of CenBio at international meetings and conferences	SINTEF-ER	2010-12-01
D5.2.9	1-3 business PhD applications	UMB	Cont.
D5.2.10	5 industry workshops	UMB	Cont.
D5.2.12	At least 10 scientific journal and conference articles to be submitted - At least 10 presentations to be produced (conference, seminar, workshop, etc)	UMB	Cont.
D5.2.13	CenBio website	UMB+SE	Cont.
D5.2.16	20 popular articles & press news and 10 presentations about CenBio	UMB+All	Cont.
D5.3.1	CenBio Innovation Plan, first edition	SINTEF-ER	2010-12-30
D5.3.2	First Innovation workshop	SINTEF-ER	2010-11-17
D5.3.3	Nomination of BIA Committee	SINTEF-ER	2010-11-17
D5.3.4	Publishing and patenting processes	SINTEF-ER	Delayed
D5.3.6	Application activities 2010	SINTEF-ER	2010-12-01
D5.3.7	The first Bioenergy Innovation Award	SINTEF-ER	2011-01-21

8.6 References

R&D Agreement between RCN and the host institution UMB
Consortium Agreement

Annual Work Plan 2010
The FME scheme (RCN website 2010-04-01)
Annual Work Plan 2011

CenBio website (www.cenbio.no)
RCN's FME-website (www.forskningsradet.no), in Norwegian (in English)