

Technical Annex

Scientific description of the project

Title: Biomass and bioenergy production in organic agriculture – consequences for soil fertility, environment, spread of animal parasites and socio-economy.

Acronym: BioConcens

Duration: **From:** 1. January 2007 **to:** 31. December 2010

Participating scientists:

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English summary:

The production of bioenergy from local biological resources and the maintenance of soil fertility seem to have been opposing aims in organic agriculture (OA). It is however, important to reduce the reliance on fossil fuels and decrease greenhouse gas emissions in OA, especially in the context of enhanced integrity of OA.

Biogas, bioethanol, plant oils, wind energy, and biomass for combustion can be produced in OA and contribute renewable energy for self-sufficiency. Plant oils (biodiesel), biogas and bioethanol can be used as fuel for diesel engines and can be produced on-farm. Presently oilseed crops are difficult to cultivate in organic farming, due to many pests and a rather large area is required to substitute e.g. diesel in organic farming. Biogas can be produced in on-farm and co-ordinated medium or large-scale plants from animal manure and energy rich wastes. Grass-clover crops commonly grown in OA have a great potential as raw material for biogasification. Due to several barriers, biogas is not readily available as a fuel for diesel engines, but can be used to produce electricity and heat. Bioethanol produced from starch can be used as a substitute for diesel with addition of an ignition improver.

This interdisciplinary project aims at developing new methods and processes for co-production of bioethanol, biogas and animal feed based on resources from OA and associated food processing and suggests the outline of a medium-sized plant for co-production of biogas, bioethanol, and animal feed. The project will also design and test a new cropping system for biomass production to be used for bioenergy, while at the same time safeguarding soil quality. The project will analyze the effects of remains from bioenergy production on soil fertility, greenhouse gas emissions, survival of parasites and weed seeds in the manure as affected by bioenergy production. Corporate and socio-economic analysis of the co-production of biogas and bioethanol at different scales will be carried out.

The interdisciplinary project is organized in six work packages with significant interactions between WPs. WP 6 is devoted to coordination. The objectives of the five other work packages are to:

Work package 1: Co-production of biogas, bioethanol and animal feed from organic raw materials

- Convert grass-clover, animal manure, energy crops (maize and rye) and agro-industrial by-products from organic farming to biogas, bioethanol and fodder protein.
- Design processes for the co-production of biogas and bioethanol/protein fodder in an organic coordinated plant and evaluation of energy balances.

Workpackage 2: Strip intercrop system for biomass production

- Determine the effect of intercropping a grass-clover based perennial forage crop mixture and annual biomass crops in strips on the biomass and grain yields compared to sole cropping of the same species.
- Determine the interactions between intercrop border rows and associated mechanism responsible for a potentially improved crop growth resource use compared to sole cropping.
- Determine the effects of green manure from the soil fertility-building strip on the annual biomass crops and the effect of nutrients and residues recycled from biogasification on plant growth.

Work package 3: Effects of bioenergy production on soil quality and survival of parasites and weed seeds.

- Determine soil quality as affected by application of animal manure (non-treated, processed in biogas reactors or aerobically decomposed)..
- Determine trends in the effects of the manure treatments on the genetic and functional diversity of microbiota, the soil structure, and the organic matter content and its quality over the entire project period.
- Measure the capability of the biogasification in inactivating parasite eggs in the manure.
- Determine the effect of biogasification on the survival of weed seeds in manure.

Workpackage 4: Emissions of greenhouse gases from strip intercropping and green/animal manures

- Determine emissions of nitrous oxide (N₂O) associated with strip intercropping systems.
- Determine emissions of non-CO₂ greenhouse gases (N₂O and CH₄) associated with i) application of bioenergy residues for agronomic purposes, and ii) storage (pre-treatment) of green/animal manure for bioenergy utilization.
- Assess stability and C-sequestration potentials of bio-energy residues.

Workpackage 5: Scenarios for bio-energy production in organic agriculture and socio-economic analysis

- Carry out detailed partial analyses of corporate and socio-economic, environmental and energy balance effects of investigated alternatives in WP1 to WP4 within OA. The socio-economic analyses include quantification and monetization of externalities.

- Define scenarios and carry out scenario analyses of the overall corporate and socio-economic, environmental and energy balance consequences of integrating biogas production and bioethanol production in OA.

A.0 Introduction, state of the art and objectives of the project:

Introduction

Energy production and use in organic agriculture (OA) should be addressed in order to reduce the reliance on non-renewable fossil fuels and greenhouse gas (GHG) emissions (Jørgensen and Dalgaard, 2004). The development of renewable energy technologies within OA has been slow. One of the reasons for this has been concern in the organic community, that soil fertility will decline if a major part of the organic residues is used for bio-energy production and only residues from anaerobic gasification are recycled (Salomonsen, 2000). Since soil fertility is the basis for OA, organic materials should be recycled to the soil to preserve fertility. Using organic sources for energy production can potentially diminish the amount of carbon and nutrients recycled to the soil (Christensen et al., 1996; 2002). However, it is possible to manage soil fertility by intelligent management of organic residues and crop rotation. It is in agreement with the precautionary principle not to implement new technologies without knowledge of their consequences (DARCOF, 2000). Principles should not be a barrier for research on sustainable energy technologies within OA, since the reduction of non-renewable fossil energy use and reduced greenhouse gas emissions agriculture are principal aims in OA. Thus, there is an obligation to find consensus between the apparently opposing aims of renewable (bio) energy production and soil fertility in OA. This project aims of designing and evaluating a combined concept for biomass and bioenergy production in OA, while considering soil fertility.

State of the art

Substituting direct fossil energy use in organic agriculture with renewable energy

A thorough examination of fossil energy use and perspectives for production of energy from local resources in OA has recently been published by DARCOF (Jørgensen and Dalgaard, 2004). They estimate that the total energy use in Danish OA is close to 2.5×10^{15} J, of which 17 million L diesel and 30 million kWh power are direct energy. They suggest that biogasification of animal manure and grass-clover pastures can become a major renewable energy source in OA and potentially cover 72% of the energy requirements. It is estimated that 19,000 ha grass-clover pasture is required to cover 40% of the total or 77% of the direct energy use in OA (Jørgensen and Dalgaard, 2004). This corresponds to 12% of the Danish organic area. In Sweden, the consumption of 36 million L diesel in OA can potentially be substituted from biogas deriving from all OA animal manure and grass-clover from ca. 19,000 ha (6% of organic area) (Baky et al., 2002). Bernesson (2004) carried out life cycle analyses for production of fuels in OA and found that biogas production from grass-clover had the lowest land use and relatively low cultivation and soil-related emissions. Diesel engines can run on bioethanol and cleaned biogas, but large storage facilities are required for biogas, and on-farm consumption of fuel for machinery is very seasonal (Baky et al., 2002). Furthermore, compression of biogas to 200-250 bar is a prerequisite for use as fuel, accounting for ca. 10% of the biogas energy (Møller and Sommer, 2004). Co-producing biogas and bioethanol in a coordinated bioenergy plant might be a more optimal solution.

Co-production of biogas and bioethanol

Anaerobic digestion of manure is a well-known technology for biogas production. Apart from a significant energy production the technology results in reduced GHG emissions, improved nutrient utilisation when recycling the residue to the field and reduced odour. Since manure is poor in energy components (sugars and lipids), it is necessary to mix it with substances containing more energy *e.g.* waste from food industry. Grass-clover pasture can be used as an alternative energy rich waste, for biogas production using cuts taken at an early growth stage, since the most easily digestible sugars are present in the leaves before stem production in June/July (Larsen, 2004). Sommer et al. (2002) estimated that in biogas production from grass-clover pastures, >10 times more energy is produced than utilized in the energy balance, corresponding to an energy output of ca. 13,000 kWh per ha. Maize silage is a resource with great potential. With a gentle pre-treatment (method to be developed within the project) using ammonia from manure for delignification, it is expected that the potential energy output from maize silage will exceed that of grass-clover pastures. Deep litter contains huge amounts of partly degraded straw, which is rich in energy components (up to 80% sugar polymers), and which are potential substrates in a biogas production (Thomsen et al., 2003). Thus, mixing deep litter and slurry enhance biogas the yield.

The hydrolysis of sugar polymers, proteins and lipids is the rate-limiting step in biogas production, due to lignin associated with the sugar polymers (Tong et al., 1990). However, straw is sensitive to ammonia (high pH) treatment, that opens up the lignin barrier and improves sugar hydrolysis and fermentation yields (Thomsen et al. 2003). A pretreatment process will be developed to increase sugar hydrolysis and thereby the biogas yield from maize silage and animal manure. Whey is a by-product of cheese production and whey-permeate is a liquid waste product from the production of whey-protein. Whey-permeate contains lactose (< 4.6%), minerals (0.5%) and lipids (0.05%). Whey-permeate is presently used for biogas production and pig feed. We will test whey-permeate as a water resource alternative to manure for biogas and ethanol production with co-production of protein fod-

der. It has been shown that the content of amino acids increases by 230%, and lysine by 300% after biogas production from grass-clover pasture (Gunnarson and Stuckley, 1986).

The most well-known and easiest way to produce bioethanol is by the enzymatic hydrolysis and fermentation of starch. In this process more than 34 mill. m³ of ethanol were produced in 2002 for transportation fuel, accounting of 60% of the total world ethanol production (Thomsen et al., 2003). The estimated production of bioethanol from wheat is 1 m³ per hectare. In the present project, a combined ethanol and biogas production will be developed for organic farming using starch containing biomass (maize and rye) and whey-permeate as water resource with co-production of animal fodder. Natural enzymes from cereals will be used for hydrolysis of starch to glucose in accordance with technology in brewing technology (Briggs, 1981). Commercial enzymes are often produced from gene-modified organisms and will not be used in the project.

Cropping systems for biomass production

Energy crops and crop residues are renewable energy sources, which can reduce the consumption of fossil fuels. However, it is important to minimize the energy use and CO₂ emissions during the production of crops. Organic plant production is based on healthy rotations, but crops are typically sole cropped (except for pastures) in large fields. Crop diversity in time (rotation) and space (field size and intercropping of species/cultivars) can contribute to safeguarding yield stability and soil fertility, lowering nutrient emissions and reducing weeds, diseases and pests in the cropping systems (Hauggaard-Nielsen et al., 2001; 2003; Karlen et al., 1994, Willey, 1979). Intercropping was common in developed countries before the 'fossilisation' of agriculture (Cassman, 1999; Matson et al., 1997). Intercropping of plant species (planned diversity) enhances the possibility to use ecological mechanisms such as diversity, competition, facilitation and complementarity in crop production (Vandermeer, 1989). Furthermore, implementation of intercrops in agroecosystems has been shown to increase diversity of microbes, flora and fauna, which often have a positive impact on crop productivity (Vandermeer, 1995).

In this project a strip intercrop system for biomass production is developed. Strip intercropping is defined as the practice of producing two or more crops in strips wide enough that each can be managed independently, yet narrow enough that the strip components can interact. The hypothesis is that the interactions (physical, biological, ecological, management) between components of a system with greater spatial diversity will enhance biomass yield, resource use while decreasing the emissions of GHG compared to sole cropping of the same species. A perennial (2-yr) soil fertility building (SFB) strip (forage legumes, grasses) and a strip consisting of either maize or winter rye -winter vetch intercrop will be chosen to produce biomass for biogas and bioethanol. The perennial strip will enhance soil fertility, extract nutrients from deeper soil layers, fix N₂ and compensate for the effect of annual crops on soil fertility and also reduce the requirement for soil tillage. In addition all crops can alternatively be used for feed in organic milk production.

Effect of residues from biogasification on soil quality parameters

Organic agriculture depends on a high level of soil fertility to sustain crop production, while at the same time maintaining a microbiota with a high degree of diversity. The activity and catabolic capabilities/diversity of the soil microorganisms are pivotal in OA in order to drive the cycling processes (decomposition) of plant nutrients (Nannipieri et al., 2003; Wardle and Giller, 1996). Soils are amended with complex organic materials (e.g. composted plant material or animal manure) with a high C content and slow release of N. In contrast, remains from biogas production have a decreased C content and the N is more available to plants and the soil microbiota and, hence, N leaching and degradation of the soil humus content is of concern (Salomonsen, 2000). The present knowledge on this issue is sparse. Soil microbial indicators (e.g. microbial biomass, soil enzymes, qCO₂, mycorrhizas) or macrofaunal (e.g. earthworms; nematodes) are considered useful and sensitive/responsive indicators of soil quality (Mäder et al., 2002; Brussard et al., 2004; Oehl et al., 2004; Johansen et al., 2005). Soil aggregate stability has shown measurable short-term response to soil management (Mäder et al., 2002) comparable to the treatments planned in the present project. When measuring genetic and functional diversity of the entire soil microbiota the phospholipid fatty acid (PLFA) and catabolic response profiling techniques seems most useful (Zelles, 1999; Johansen and Olsson, 2005; Degens et al., 2000).

Effect of biogasification of animal manure on spread of animal parasites and survival of weed seeds.

Organic pigs and cattle are in general more parasitized than conventional indoor production (Thamsborg et al., 1999). Eggs of intestinal parasites are spread via faeces while grazing or through field application of organic manure. While infective larvae of the most prevalent cattle nematodes are relatively short-lived, the infective stages of the pig nematodes *Ascaris suum* (a zoonose) is common in organic pigs (Roepstorff et al., 1992; Carstensen et al., 2002) and may survive for up to 9 years (Krasnonos, 1978). The resistance of *Ascaris* eggs against environmental factors is generally much stronger than that of bacteria and viruses, and thus *Ascaris* is often used as an indicator when evaluating the inactivation capabilities of sludge processing plants (e.g. Black et al., 1982; Carrington et al., 1991). The ability of weed seeds in manure to germinate may also be impaired by biogasification

(Gunaseelan, 1998; Sarapatka et al., 1993). Animal manure is regarded as a major source of weed seeds that return to the soil (Jørgensen and Dalgaard, 2004.).

Emission of GHG from crop production with and without amendment with organic materials

Agricultural production is a strong source for emissions of nitrous oxide (N₂O), which has important effects on atmospheric chemistry and radiative properties (Baggs et al., 2002). Particularly high emissions are observed when manure, slurry and fertilizers are applied to the soil (Ball et al., 2004). Incorporation of plant residues has also been demonstrated to induce emissions of N₂O, the extent of which is dependent on the residue quality and quantity, and incorporation technique (Ambus et al. 2001; Baggs et al., 2002). Low-input cropping systems, with particular emphasis on legume-based systems, have therefore been suggested as a mitigation option to reduce agricultural N₂O emissions, but systematic long-term measurements in such systems are sparse. Low N₂O emissions have been observed from grass-clover pastures (Ambus 2005), but an overall N₂O budget for a grass-legume rotation is not available. Animal husbandry is also a strong source of N₂O, which is emitted in significant amounts e.g. from manure storage and compost piles (Czepiel et al., 1996; Wolter et al., 2002; Thompson et al., 2004). Biogasification of animal manure changes the chemical composition of the waste material, which may have implications for GHG emissions from subsequent field applications. Petersen (1999) found reduced N₂O emissions with anaerobic digested slurry, presumably because less C was available for microbial activity. Likewise, agricultural activities influence the emissions of methane (CH₄) that also have significant implications for atmospheric chemistry. Large CH₄ emissions are mainly associated with ruminant activity and short episodic events following applications of organic waste materials (Ball et al., 2004; Ambus et al., 2001). Manure storage piles (Wolter et al., 2004), compost piles (Thompson et al., 2004) and slurry tanks (Petersen et al., 2005) are also strong point sources of CH₄. Optimization of plant production management with reduced N-inputs and treatment of organic wastes, such as biogasification thus has a significant potential for reducing agricultural GHG emissions.

Nitrate leaching from organic systems

Nitrate leaching from organic milk production systems are generally lower than from conventional systems, due to a lower intensity of both crop and animal production and the widespread use of catch crops (Eltun et al., 2002, Kirchman and Bergstrøm, 2001). Recent Danish analyses have shown that differences are small between conventional and organic farms with plant production only (Berntsen et al., 2003). Perennial leys in the rotations contribute to reducing nitrate leaching during their growth, but the year following the breaking of the ley constitutes a high risk of enhanced nitrate leaching.

Socio-economic analysis

Biogas and bio-ethanol projects have socio-economic implications not only in the agricultural sector, but in the industrial and energy sectors as well. Amongst the environmental consequences, mitigation of pollution, GHG emission reduction and reduced eutrophication of ground water etc. are important external effects (Nielsen et al., 2002). The socio-economic analysis looks at the project or activity in question from the point of view of the society in its entirety, and takes in principle into account all so-called externalities (Lesourne, 1975). Externalities or external effects neither imply expense nor income elements for the corporate or private investor. However, externalities are important economic effects seen from the point of view of the society. A project may inflict burdens on or contribute gains to society, relative to the reference activity, which must be taken into account when evaluating a project from the point of view of the society.

Objectives

BioConcens aims at analyzing and suggesting solutions to the apparent opposing aims of bioenergy production and safeguarding soil fertility in OA. The main objectives are:

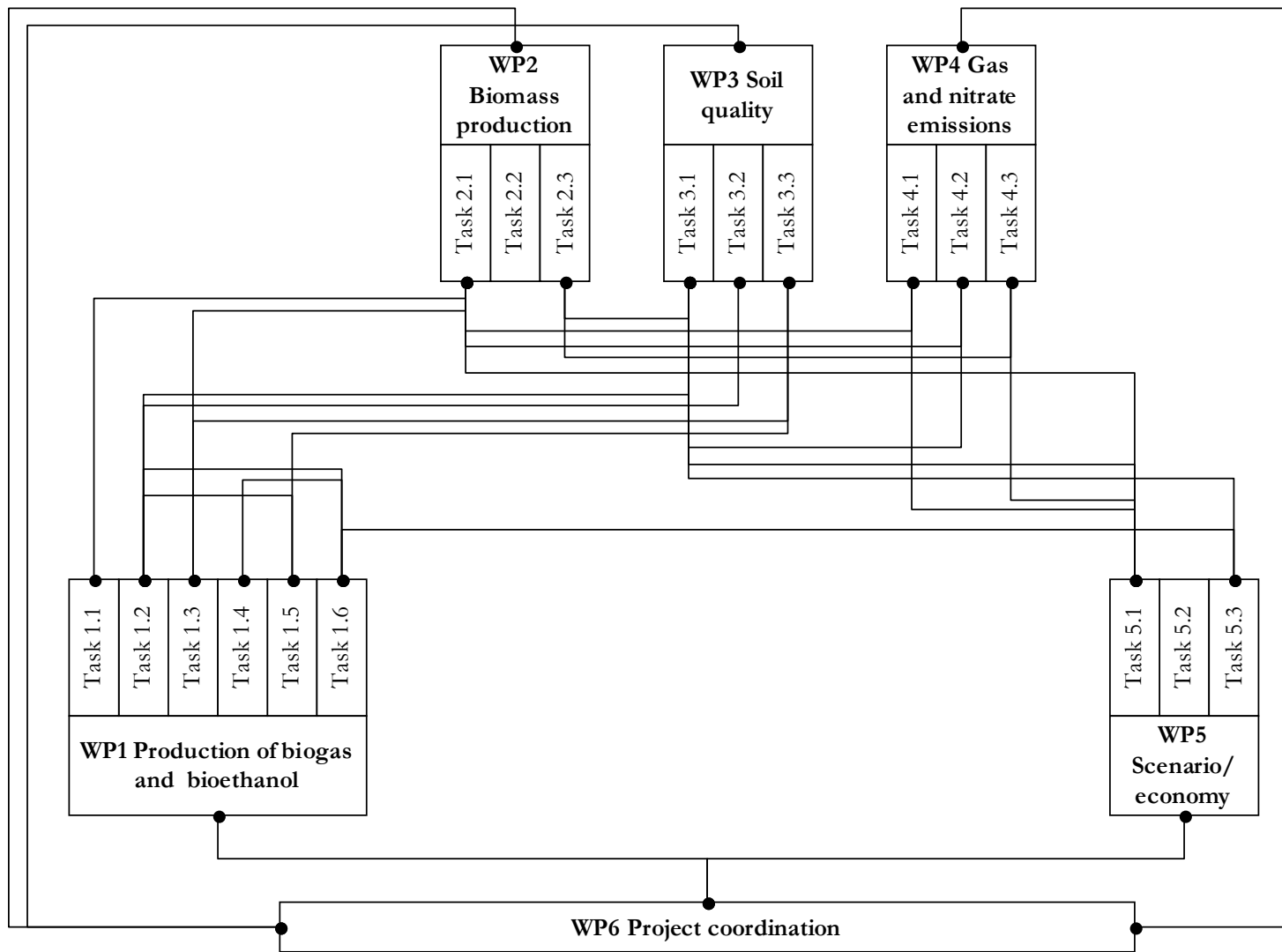
- To determine the potential of local co-production of bioethanol, biogas and protein feed from grass-clover, winter rye, maize, animal manure and recirculated by-products from the organic agro-industry in laboratory scale studies and to design a co-ordinated medium-scale plant for bioenergy production in organic agriculture.
- To design strip intercropping systems for biomass (bioenergy) production and measure their productivity, evaluate their effects on soil fertility and plant interactions.
- To determine the potential effects of recirculated residues from biogasification into strip intercrop systems on plant growth, soil quality parameters and GHG and of biogasification on the survival of animal parasites and weed seeds.
- To develop scenarios and make socio-economic analyses for bioenergy production in organic agriculture.

A.1 Relevance for DARCOF III and argumentation for the subject:

The project covers the complete content of the research project theme 3.6.1 “Bioenergy as a complement to food production”. In addition to the call content the project includes production of liquid fuel (bioethanol) and includes the design and development of a new and innovative strip intercrop systems for biomass to energy and food production with a greater spatial diversity in organic agriculture. The research is relevant in relation to other research themes in the call materials (3.5.1. Cropping systems and 3.5.2 Multifunctional goods from organic agriculture.). The relevance of the project for organic agriculture is high since it address the question of energy production and use. The project can contribute to improve integrity of organic farming by reducing the need for fossil energy resources.

A.2 Technical content of the research activity

Perth diagram: Overview of the project structure and interactions



Gantt diagram: Time schedule for work package activities, milestones and deliverables

Work- package	Year 1						Year 2						Year 3						Year 4							
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48		
	F	A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D	F	A	J	A	O	D		
1	1	[Activity]																								
	2							1.1	[Activity]							1.4	[Activity]									
	3													1.2	[Activity]									1.6	[Activity]	
	4		[Activity]						1.2	[Activity]			1.3	[Activity]										1.5	[Activity]	
	5											1.1	[Activity]			1.3	[Activity]									
	6	[Activity]																	1.7	[Activity]						
2	1											2.1	[Activity]					2.1	[Activity]					2.4		
	2														2.2	[Activity]						2.2	[Activity]	2.5		
	3																	2.3	[Activity]			2.4	[Activity]	2.3		
3	1		3.1				[Activity]								3.2	[Activity]					3.3	[Activity]			3.4	
	2							3.2			[Activity]			3.1	[Activity]							3.3	[Activity]		3.5	
	3										3.4	3.5	3.6	[Activity]			3.7	[Activity]								
4	1		4.1			[Activity]				4.1	[Activity]					4.1	[Activity]		4.2	4.1	[Activity]					
	2		[Activity]	[Activity]	[Activity]	[Activity]						4.2	[Activity]							4.3	4.3	[Activity]				
	3																	4.3	4.3	[Activity]						
5	1											5.1	[Activity]					5.2	5.4	5.3	5.3	[Activity]				
	2																	5.5	5.6	5.1	5.9	5.4	[Activity]			
	3																	5.7	5.8			5.10	5.5	5.11	5.2	
Meeting		[Milestone]				[Milestone]																		[Milestone]		

- [Light Gray Box] = activity
- [Dark Gray Box] = milestones
- [Black Box] = deliverables

Work Package list

WP No.	WP title	Responsible scientist	Budget mill. DKK	Start	End	Deliverable No.
1	Co-production of biogas, bio-ethanol and animal feed from organic raw materials	Anne Belinda Thomsen (ABT)	4.838	Jan 07	Dec 10	D1.1-D1.7
2	Strip intercropping system for biomass production	Henrik Haugaard-Nielsen (HHN)	2.155	Jan 07	Dec 10	D2.1-D2.4
3	Effects of bioenergy production on soil quality and survival of parasites and weed seeds.	Anders Johansen (AJ)	2.524	Jan 07	Dec 10	D3.1-D3.7
4	Emissions of greenhouse gases from strip intercropping and green/animal manures	Per Ambus (PA)	2.278	Jan 07	Dec 10	D4.1-4.4
5	Scenarios for bioenergy production in organic agriculture and socio- economic analysis	Lars Henrik Nielsen (LHN)	2.100	Jan 07	Dec 10	D5.1-D5.5
6	Coordination	Erik Steen Jensen (ESJ)	105	Jan 07	Dec 10	D6.1-D6.2
Total			14.000			

Deliverables list

Deliverable No	Deliverable title	Lead scientist	Delivery date	Months per deliverable	Type of deliverable
D1.1	Paper on pilot scale experiments with biogas and protein production from energy crops	ABT	M24	2	S
D1.2	Development and validation of a model for digestion of biomass for energy and protein.	ABT	M26	14	S
D1.3	Paper on new designs for high dry-matter anaerobic digestion systems of biomass.	ABT	M30	2	S
D1.4	Paper on potential biomass, crops and wastes from organic farming for biogas production.	ABT	M31	5	S
D1.5	Paper on combined biogas and ethanol production using most relevant biomass materials from organic farming.	ABT	M44	14	S
D1.6	Paper on combined biogas and protein fodder production in organic farming using grass-clover and whey-permeate as raw materials.	ABT	M45	3	S
D1.7	2 Ph.d. theses including aspects of “combined biogas, ethanol and protein production in organic farming”.	ABT	M42	32	R
D2.1	Paper on the effects of strip intercropping concept with perennial diversified grass-clover strip and annual maize and winter rye-winter vetch intercrop as energy crops	HHN	M36	10	S
D2.2	Report on the competitive interactions between strips of perennial diversified grass-clover and annual maize and winter rye-winter vetch intercrop with special emphasis on light and water utilization	HHN	M44	4	R
D2.3	Paper on resource use by annual-perennial strip intercrop system for bioenergy production as influenced by application of grass-clover green manure and residues from biogasification	HHN	M47	10	S
D2.4	Dissemination in farmers magazines on the potential benefits of strip intercropping	HHN	M48	1	O
D3.1	Paper on short-term effects of manure treatment (composted/degassed) on soil quality biological indicators.	AJ	M26	9	S
D3.2	Paper on effects of manure treatments (composted/degassed) on soil fertility.	AJ	M32	4	P
D3.3	Paper on remains from biogas/bioethanol production effects on soil quality biological indicators.	AJ	M40	8	S
D3.4	Paper describing the development of soil quality parameters (biological and soil structure) on longer terms as affected by the types of manure application.	AJ	M48	6	S
D3.5	Paper evaluating the soil quality parameters used in the project.	AJ	M46	4	S
D3.6	Report on the capacity of bioenergy-generating reactors in inactivating parasite eggs.	AJ	M26	4	R
D3.7	Report on effect of pretreatments and biogasification on weed seed survival	AJ	M32	4	R

Deliverable No	Deliverable title	Lead scientist	Delivery date	Months der deliverable	Type of deliverable
D4.1	Dataset for N ₂ O emissions from strip-intercropping for evaluation of management practice (WP2) and sustainability (WP5)	PA	M16,28,36	16	O
D4.2	Knowledge on N ₂ O and CH ₄ emissions from biomass pre-treatment and post application of remains to evaluate sustainability (WP5)	PA	M24, 36	7	O
D4.3	Assessment of the degradability and C-sequestration potentials of bioenergy waste for evaluation of soil fertility (WP3)	PA	M36	7	O
D4.4	Paper on N ₂ O emissions from strip-intercropping (M 40)	PA	M42	2	S
D5.1	Economic assessment of bio-ethanol and biogas production in organic agriculture.	LHN	M42	7.15	S
D5.2	Scenarios for bio-energy production in organic agriculture and socio economic analysis.	LHN	M52	7.15	S
D5.3	Energy catchment farm database and GIS-map	TDA	M38	3.6 (1.4)	O
D5.4	Paper submitted on dynamic modelling of the effects of bioenergy production on crop production, nitrate leaching and greenhouse gas emissions	JEO	M46	3.6 (1.4)	S
D5.5	Paper submitted on the multifunctional role of bio-energy production in organic agriculture. An energy catchment case study (co-deliverable with the DARCOFIII financed project Refugia).	TDA	M48	3.6 (1.4)	S
D6.1	Annual Reports	ESJ	M13, 26,37,48	0.5	R
D6.2	Popular articles (7/year)	ESJ	M12, 24, 36, 48	0.5	R

(The nature of the deliverables must be indicated by S = publication in scientific journal with peer review; P = publication in journals without peer review; R = reports; C = presentation at meetings and congresses or O = other types of deliverables, e.g., prototypes, models, websites, etc.).

Milestones list

Milestone No	Milestone title	Lead scientist	Delivery date
M1.1	A biogas process for efficient utilization of energy crops and manure in organic farming	ABT	M15
M1.2	Development of a digester running on energy crops with high dry matter	ABT	M15
M1.3	Development of natural enzymes for ethanol production in organic farming	ABT	M25
M2.1	Preliminary evaluation of the effect of strip intercropping perennials with annual bioenergy crops has been determined	HHN	M24
M2.2	Light and water utilization between intercropped strips has been determined	HHN	M30
M2.3	The effect of organic residue from green manure, animal manure and biogasified animal manure on energy crop yield has been determined	HHN	M36
M2.4	Characterization of N conservation by growing maize as compared to winter rye-winter vetch mixture in strip intercropping systems	HHN	M42
M2.5	Guidelines for annual-perennial strip intercropping systems for multiple functions in organic cropping systems	HHN	M48
M3.1	Field small-scale facility established	AJ	M10
M3.2	Data set for short-term effects of manure and waste materials from bioenergy-generating reactors on soil biota	AJ	M18
M3.3	Results on long-term effects (field experiment) on manure/cropping system effects on soil quality	AJ	M40
M3.4	Data set on effect of biogasification processes on the survival of weed seeds	AJ	M22
M3.5	Termination of the parasitological analyses	AJ	M24
M4.1	Established gas flux chambers in strip-intercropping system	PA	M8
M4.2	Achieved data for field emissions of N ₂ O	PA	M34
M4.3	Completed point-source measurements of N ₂ O, CH ₄ and CO ₂	PA	M34
M5.1	Method completion and detailed definition of reference and alternative scenarios.	LHN	M 28
M5.2	Definition of grass clover production systems to be modelled, and Selection of a relevant area for the energy catchment analyses, and definition of the farm data to be required from central databases	TDA	M 32
M5.3	Completion of model tools developments in accordance with desired level of description. This includes adapting of the FarmGHG and the FASSET model to the grass clover systems defined	JEO	M 36
M5.4	Completion of data collection for partial analysis of corporate and socio-economy of biogas production within organic agriculture.	LHN	M 34
M5.5	Completion of data collection for partial analysis of corporate and socio-economy of bio-ethanol production within organic agriculture.	LHN	M 38

M5.6	Results on: Partial analysis of economy of biogas production within organic agriculture.	LHN	M 40
M5.7	Results on: Partial analysis of economy of bio-ethanol production within organic agriculture.	LHN	M 38
M5.8	Results on: Analysis of economy of combined bio-ethanol and biogas production within organic agriculture.	LHN	M 40
M5.9	Model results on crop production, nitrate leaching and greenhouse gas emissions from the grass clover energy production systems defined	JEO	M44
M5.10	Results on the multifunctional role of bioenergy production in the energy catchment	TDA	M46
M5.11	Model results on: Scenarios for bio-energy production in organic agriculture and socio economic analysis.	LHN	M 50
M6.1	Annual project meetings	ESJ	M3, 11, 23, 35, 45

Description of work packages

WP No.: 1 Co-production of biogas, bioethanol and animal feed from organic raw materials

	Start date or starting event: January 2007								
Partner id.	Risø	DTU	DIAS						
Person-months per participant	56 VIP 13 TAP	1.6 VIP 4.8 TAP	14.5 VIP 6.5 TAP						
Total PM VIP:	72.1								
Total PM TAP:	24.3								

Objectives:

- Conversion of grass-clover, animal manure, energy crops (maize and rye) and agro-industrial by-products from organic farming to biogas, bioethanol and fodder protein in laboratory and full scale studies.
- Design of a process for co-production of biogas and bioethanol/protein fodder and evaluation of energy balances.

Description of work:

Task 1.1 Biogas and bioethanol potentials of selected raw materials

Characterization of biomass (grass-clover, grass, maize, maize stover, winter rye), residues and by-product streams (whey permeate, slurry, deep litter animal manure) for biogas and/or bioethanol production in organic farming. Chemical analysis will be made for the selected raw materials and the theoretical biogas and ethanol potentials will be calculated.

Task 1.2 Biogas production

Development of a technology for 15-30% improved biogas production from combined mixtures of slurry (manure, whey, liquid by-product streams from bioethanol production) and deep litter animal manure and grass-clover. Simple pretreatment technology using long residence time at elevated temperature will be examined for further conversion efficiency (improved biogas yield) and to eliminate the spread of parasites as well as reduce germination of weed seed. Waste streams from the bioethanol production (task 4) containing residual sugars (including C5) together with other by-products such as carboxylic acids and fats will be converted to biogas. Biogas tests will examine the biogas yield on produced media at mesophilic and thermophilic conditions. The final residues (solid and liquid) from the biogas treatment enriched in lignin substances and nutrients will be analysed and recycled to the fields as soil improvement material and fertiliser.

Task 1.3 Co-production of biogas and fodder protein

Development of a biogas process based on whey-permeate and grass-clover for combined biogas and fodder protein production. Whey-permeate containing lactose and minerals will serve as water and nutrient supplies in this biogas production; animal manure is not used in this process as the protein product will be used for fodder. The energy containing substrate is clover grass, which will be mixed with the whey-permeate before the biogas reactor to ease handling. The biogas yield will be measured and the protein composition of the solid co-product will be analyzed. This is expected to contain protein rich in lysine, which is a special requirement in especially organic pig production.

Task 1.4. Co-production of biogas and ethanol

Development of an “easy to handle” technology for bioethanol production from biomass (grain of maize and rye), crops (silage of clovergrass and maize stover) and agro-industrial by-products (whey-permeate) with C6-sugar contents. This will focus on simple simultaneous saccharification and fermentation (SSF) of C6 by using Bakers yeast and natural enzymes produced from germination of grain. Whey-permeate or degassed, sterilized manure from biogas production will be used as a water and nutrient source in the bioethanol production, so no extra costs will be needed for these key process parameters. Residual solids and by-products including carboxylic acids are expected to be recycled and converted to biogas in task 2. Analyses of products and energy balances (task 6) will examine the most relevant utilization.

Task 1.5: Pilot and full scale tests

In this activity selected biomasses and combination of biomasses, will be tested in pilot scale and full scale reactors. The operation conditions of pilot scale reactors will be set to the optimum as determined from the results of lab scale experiments. The digesters will run on manure, mixtures of manure and energy crops or with only energy crops. The following processes will be studied:

- a. Concepts with a mixture of energy crops, manure and waste streams like whey permeate
- b. Combined biogas and protein production.

The different degrees of up-scaling are illustrated in the table.

Table: Experiments with up-scaling

	Laboratory and pilot scale (120 l dig.)	Pilot digester (10 m ³ dig.)	Full scale dig. (500 m ³ dig.)
Co-digestion of manure and energy crops	X	X	X
Combined protein and biogas production from energy crops	X		

During the pilot scale reactor experiments several parameters will be monitored like biogas production, methane content, process state indicators (VFA, pH, alkalinity) and nutrient availability (nitrogen and ammonium) in the digested product. The protein from the combined energy and protein production will be upgraded and the feed quality evaluated in terms digestibility and protein value for pigs by in vitro analysis. The digestion with energy crops will be done both in a pilot digester developed for high dry-matter content and in a system where the energy crops are mixed with a dilute waste stream or by recycling of liquid digested biomass. From some of the concepts sufficient material will be digested for the experiments with intercropping.

Task 1.6. Evaluation of combined biogas and protein/bioethanol production (ph.d.-project)

A combined biogas and bioethanol/protein production using most relevant substrates (including waste streams from Task 2, 3 and 4) will be designed and evaluated for an optimised economic process based on high yields (biogas, protein and bioethanol) and low energy input in the processes. This will be compared to biogas production without co-production.

Deliverables:

- D1.1 Paper on pilot scale experiments with biogas and protein production from energy crops (Months M 24).
- D1.2 Development and validation of a model for digestion of biomass for energy and protein (M 26)
- D1.3 Paper on new designs for high dry-matter anaerobic digestion systems of biomass (M 30).
- D1.4 Paper on potential biomass, crops and waste from OF for biogas production (M 31).
- D1.5 Paper on combined biogas and ethanol production using most relevant biomass materials from organic farming (M 44).

- D1.6 Paper on combined biogas and protein fodder production in organic farming using clover grass and whey-permeate as raw materials (M 45).
- D1.7 2 Ph.d. theses including aspects of “Combined biogas, ethanol and protein production in organic farming” (M 42).

Milestones:

- M1.1 A biogas process for efficient utilization of energy crops and manure in organic farming (M 15).
- M1.2 Development of a digester running on energy crops with high dry matter (M 15).
- M1.3 Development of natural enzymes for ethanol production in organic farming (M 25).

WP2: Strip intercropping system for biomass production

	Start date or starting event: January 2007									
Partner id.	Risø									
Person-months per participant	25 VIP 7 TAP									
Total PM VIP:	25									
Total PM TAP:	7									

- Objectives:**
- To determine the effect of intercropping a grass-clover based perennial forage crop mixture (soil fertility building crop) and annual biomass crops in strips on the biomass and grain yields compared to sole cropping of the same species.
 - To determine the potential interactions between intercrop border rows and associated mechanisms responsible for a potentially improved resource use (e.g. nutrients, light, water) compared to sole cropping.
 - To determine the effects of green manure from the soil fertility-building strip on the annual biomass crops and the effect on plant growth of nutrients and residues recycled from biogasification.

Description of work

Task 2.1. Strip intercropping of perennial grass-clover pasture and cereals

A 2-year grass-clover based perennial forage crop mixture (soil fertility building [SFB] strip) will be strip intercropped (6 m strips) with annual biomass crops for energy production (maize and winter rye-winter vetch intercrop) in field plot experiments, with a north-south row direction to increase the interception of light in the energy crop strip. After two years the strips are interchanged and subsequent first year maize and winter rye-winter vetch intercrop will be sown in the previous grass-clover strips besides a new SFB strip in the strips previously grown with biomass crops. Two circles of the strip intercrop system will be established. The advantages from strip intercropping will be determined using relative index such as the land equivalent ratio. All samplings will be conducted in individual rows to be able to determine individual crop row yields as a function of distance to the other strip. The following parameters will be evaluated: biomass yield at tillering, flowering and maturity (incl. grain yield and energy content; kJ ha⁻¹) for both strips, strip intercrop energy balance and yield stability as compared to sole crops. Total use of nitrogen sources (soil N and N₂ fixation) and crop N balance will be measured for the final harvest. The field experiment will be carried out in the DARCOF funded organic rotations at KVL, Tåstrup.

Task 2.2. Interactions between intercropped strips

Using the task 1 field trial partial analysis for utilization of environmental growth resources will be conducted with special emphasis on interactions between intercropped strips: i) Light capture ability will be estimated through plant heights and light interception measurements using a line quantum sensor at key phenological growth stages. ii) Neutron probes will be used for determining the soil water content and the water use of the cereal will be estimated from the leaf area using a light area meter. iii) Soil N, P and K uptake by the energy crops will be determined in aboveground plant materials at maturity using standard methods

Task 2.3. Green manuring and recycling of biogas residues

Effect and utilization of green manure from the SFB strip together with comparisons of recycling of composted and biogasified deep litter (WP1) will be evaluated as dry matter production at tillering, flowering and maturity stages including total nitrogen accumulation of the energy crops at maturity. Special emphasis will be placed on interactions between intercropped strips as compared to the respec-

tive sole crops. Materials for larger field plots will be derived from organic farm with farm plant for biogasification. This task will be performed in close connection with soil quality studies in WP3 and emissions of N₂O and CH₄ in WP4.

Deliverables:

- D2.1 Paper on the effects of strip intercropping concept with perennial diversified grass-clover strip and annual maize and winter rye-winter vetch intercrop as energy crops (M 36)
- D2.2 Report on the competitive interactions between strips of perennial diversified grass-clover and annual maize and winter rye-winter vetch intercrop with special emphasis on light and water utilization (M 44)
- D2.3 Paper on resource use by annual-perennial strip intercrop system for bioenergy production as influenced by application of grass-clover green manure and residues from biogasification (M 47)
- D2.4 Dissemination in farmers magazines on the potential benefits of strip intercropping (M 48)

Milestones:

- M2.1 Preliminary evaluation of the effect of strip intercropping perennials with annual bioenergy crops has been determined (M 24)
- M2.2 Light and water utilization between intercropped strips has been determined (M 30)
- M2.3 The effect of organic residue from green manure, animal manure and biogasified animal manure on energy crop yield has been determined (M 36)
- M2.4 Characterization of N conservation by growing maize as compared to winter rye-winter vetch mixture in strip intercropping systems (M 42)
- M2.5 Guidelines for annual-perennial strip intercropping systems for multiple functions in organic cropping systems (M 48)

No.: 3 Effects of bioenergy production on soil quality and survival of parasites and weed seeds.

	Start date or starting event: January 2007								
Partner id.	NERI	KVL							
Person-months per participant	35 VIP	4 VIP 4 TAP							
Total PM VIP	39								
Total PM TAP	4								

Objectives:

- To determine soil quality as affected by application of animal manure (non-treated, processed in biogas reactors or aerobically decomposed).
- Determine trends in the effects of the manure treatments on the genetic and functional diversity of microbiota, the soil structure, and the organic matter content and its quality over the entire project period.
- To measure the capability of biogasification processes in inactivating parasite eggs in the manure (especially *Ascaris suum*, which acts as an indicator organism).
- To determine the effect of biogasification on the survival of weed seeds in manure.

Description of work:

Task 3.1. Effects of manure treatments and intercropping on soil quality.

Micro-plots (MP) will be established, together with WP4, that allow detailed studies of the soil microbiota, mineral nutrient content and emissions of C and N. The experimental units will be embedded in the strip intercropping system scheduled in WP2. The micro-plots will be amended with deep litter animal manure subjected to the following treatments: 1) non-treated, 2) aerobically decomposition (composting) in heap, 3) anaerobic biogasification. A common batch of deep litter will be used in all the treatments to ensure optimal basis for later interpretation of results. WP3 will co-operate with WP5 on optimising sampling and data generation to ensure that the data are operational for analysis of sustainability and societal aspects. Microplots will be sampled regularly during the entire project and the soil analysed according to Table 1 below.

Table 1. Parameters assayed and methodology used	Micro-plots	Lab. Scale experiments
Soil organic matter content (total, soluble fraction)	X	X
Aggregate stability (wet sieving)	X	
Genetic diversity of microbiota and microbial biomass (phospholipid fatty acid technique)	X	X
Functional diversity of microbiota (catabolic fingerprinting, SIR)	X	X

The C and N content in the different manure and waste materials will be measured and their fate followed after application to the soil. The structure and activity of the entire microbial community will be measured and related to nutrient cycling processes as well as C and N emissions (measured in WP4). A consistent development in these parameters over the entire project period will indicate the longer-term effects of the different treatments on the soil quality.

Task 3.2. Effects of residues and nutrients from biogas/bioethanol production on soil microbiota.

Detailed laboratory studies (in mesocosmos under controlled environmental conditions) will be performed to measure the short-term effects on the soil microbiota of the manure application types that are mentioned in Task 3.1 and, additionally, the wastes from the bioethanol production. These experiments will allow assessment of the pools of mineral nitrogen in the soil and its content of dissolved organic matter. Besides plant growth, the effects on the size, structure and activity of the soil microbiota will be analysed according to Table 1.

Task 3.3. Effect of bioenergy production on parasites and weed seeds.

The inactivation capability of the bioenergy-reactors will be measured by collecting representative samples of manure before, during and at the end of the processing period, and subsequently measuring the occurrence and survival of naturally occurring parasite eggs/larvae. Manure of 1 year grazing calves and organic fatteners will be used to increase the probability of having a high number of parasite eggs. Furthermore, fresh *Ascaris* eggs will be added in small nylon bags in various locations within the reactors in order to evaluate the inactivation throughout the system. The inactivation efficacy will be evaluated by estimating egg number and viability (morphologically and by their ability to embryonate under optimal conditions).

Weed seed vigor after biogasification will be tested in green-house experiments using the seedling emergence method. Five frequently observed weed species will be mixed into animal manure, and biogasification of half of this material at raising temperatures will be compared with non-biogasified material by incorporating the organic material into soil samples, spread in trays, followed by counting and identification of weed species.

Deliverables:

- D3.1 Publication on short-term effects of manure treatment (composted/degassed) on soil quality biological indicators (M 26).
- D3.2 Dissemination in farmers magazine on effects of manure treatment (composted degassed) on soil quality biological indicators (M 32).
- D3.3 Publication on remains from biogas/bioethanol production effects on soil quality biological indicators (M 40).
- D3.4 Publication describing the development of soil quality parameters (biological and soil structure) on longer terms as affected by the types of manure application M 48).
- D3.5 Publication evaluating the soil quality parameters used in the project (M 46).
- D3.6 Report on the capacity of bioenergy-generating reactors in inactivating parasite eggs. (M 26)
- D3.7 Report on effect of pretreatments and biogasification on weed seed survival (M 32)

Milestones:

- M3.1 Field small-scale facility established (M 10).
- M3.2 Data set for short-term effects of manure and waste materials from bioenergy-generating reactors on soil biota (M 18).
- M3.3 Results on long-term effects (field experiment) on manure/cropping system effects on soil quality (M 40).
- M3.4 Data set on effect of biogasification processes on the survival of weed seeds (M 22).
- M3.5 Termination of the parasitological analyses (M 24).

WP No.: 4 Emissions of greenhouse gases from strip intercropping and green/animal manures

	Start date or starting event: January 2007									
Partner id.	Risø									
Person-months per participant	32 VIP 7.5 TAP									
Total PM VIP	32									
Total PM TAP	7.5									

- Objectives:**
- To determine emissions of nitrous oxide (N₂O) associated with the production of plant biomass in strip-intercropping
 - To determine emissions of non-CO₂ greenhouse gases (N₂O and CH₄) associated with i) the application of bioenergy residues for agronomic purposes, and ii) the storage (pre-treatment) of green/animal manure for bioenergy utilisation
 - To evaluate quality parameters and C-sequestration potential of bio-energy residues.

Description of work:

Task 4.1 Emission of N₂O from the soil to the atmosphere is measured in selected strip-intercropping components.
 Emphasis will be on the biomass strips receiving inputs of residues from biogasification and green/animal manure. The emissions will be determined in intense measuring campaigns in connection with manure applications and climatic events (rainfall) anticipated to induce substantial N₂O losses. Measurements in N₂-fixing grass-clover pasture will be carried out occasionally to validate anticipated low emission magnitudes. Gas fluxes will be determined using manual gas-flux chambers combined with GC-analysis

Task 4.2 Emissions of N₂O and CH₄ from soil applications of biomass and residues from bio-gasification
 Potentials for emissions of N₂O and CH₄ from soil applications of biomass remains from the bioethanol production and biogasification will be evaluated. Measurements will be carried out in field-plots receiving biomass remains.. Assessments of N₂O and CH₄ fluxes will also be undertaken during essential pre-treatment processes (silage/composting) of green/animal manures as well as during storage of degasified materials. Measurements will be carried out in a combination of pilot-scale and full-scale pre-treatment and storage heaps/enclosures. Storage conditions will be modified to reveal relationships between emission magnitudes and important environmental controllers (aeration, moisture, temperature).

Task 4.3 Degradability of bio-energy residues
 Lignin-containing residual from biogas and bioethanol production will be examined before recycling to the field. Analyses concern total C and N and structural components (lignin; hemi- and holocelluloses). In field plots and laboratory setups respiratory CO₂-losses will be measured during in order to evaluate degradability and carbon-sequestration potentials of the remains (WP3).

- Deliverables:**
- D4.1 Dataset for N₂O emissions from strip intercropping for evaluation of management practice (WP2) and sustainability (WP5) (M 16, 28, 36)
 - D4.2 Knowledge on N₂O and CH₄ emissions from biomass pre-treatment and post application of remains to evaluate sustainability (WP5) (M 24, 36)
 - D4.3 Assessment of the degradability and C-sequestration potentials of bioenergy waste for evaluation of soil fertility (WP3) (M 36)

D4.4 Publication on N₂O emissions from strip intercropping (M 42)

Milestones:

M4.1 Established gas flux chambers in strip-intercropping system (M 8)

M4.2 Achieved data for field emissions of N₂O (M 34)

M4.3 Completed point-source measurements of N₂O, CH₄ and CO₂ (M 34)

WP No.: 5 Scenarios for bio-energy production in organic agriculture and socio economic analysis

	Start date or starting event: January 2007								
Partner id.	Risø	DIAS							
Person-months per participant	13.8 VIP	11.3 VIP 5.2 TAP							
Total PM VIP	25.1								
Total PM TAP	5.2								

Objectives:

- To carry out detailed partial analyses of socio-economic and corporate-economic, environmental and energy balance effects of investigated alternatives in WP1 to WP4 within organic agriculture. The socio-economic analyses include quantification and monetization of externalities. Partial analyses form part of the basis for the selection and setting up of scenarios.
- To model matter flows and greenhouse gas balances for grass clover based crop rotations, and organic biogas energy production systems.
- To define scenarios and carry out scenario analyses of overall corporate and socio-economic, environmental and energy balance consequences of integrating biogas and bio-ethanol production in organic agriculture. The scenario analyses will focus on the potentials for grass clover based biogas energy production systems, and multi-functionality impact assessments of the positive and negative externalities of such systems. Furthermore, the scenario analyses will reflect overall effects of strip cropping systems and complementary energy crop production investigated in WP1 to WP4. The alternative scenarios will be evaluated relative to existing practice in organic agriculture.

Description of work:

The main objective in WP5 is to carry out externality evaluations, socio-economic analyses and corporate economic analyses of integrated utilisation of co-digestion biogas plants and bio-ethanol plants in organic agriculture in Denmark. Furthermore, the objective is to analyse energy, environmental and economic consequences of results accumulating from the WP1 to WP4, and from the grass clover based crop-rotations in the DARCOFIII CROPSYS-project. The aim is to identify and quantify the potential synergistic gains that such alternatives in combination may imply for yield, recycling of nutrients, spread of parasites, greenhouse gas emissions, and the energy balance within organic farming. The environmental evaluations will focus on the effects of grass clover based crop rotations and energy production systems, modeled on farm and energy catchment levels. The socio-economic analyses will be carried out in accordance with guidelines recommended by the Danish Ministry of Finance.

Task 5.1 Collection of data.

Collection of general data necessary for carrying out combined corporate economic and socio economic analyses covering the period 2005-2025. This concern e.g.: Forecast time series on fossil fuel price developments, heat and electricity price developments, green house gas (GHG) emission related fossil fuels, and to heat and electricity consumed in Denmark in the period. Such data will mainly be based on forecasts recommended by the Danish Energy Authority. Basic economic assumptions for the analyses on interest rates and rates of calculation, prices etc. will be based on guidelines from the Danish Ministry of Finance. This allows results from the project to be consistent with energy, environmental and economic analyses from Danish authorities. The relevant externalities for the extended socio-economic assessment of the alternatives are defined and available data on quantified and monetised externalities from Danish and international studies will be collected. For the modeling of matter flows and greenhouse gas emissions, data on GHG-emissions (CO₂, CH₄, N₂O) from handling, storage and use of liquid and solid manure in organic agriculture, and emissions from conventional agro-industry waste treatment are collected in cooperation with WP1. Furthermore, data on NH₃-emission to air and N-leakage to water environ-

ments is synthesized. Other gains and losses for society at large (e.g. related to the security of energy supplies, employment effects and effects for the trades and industries, veterinary aspects and spread of parasites, reduction of obnoxious smells, fauna diversity etc.), which are not reflected in market prices may be difficult (or impossible) to quantify for the socio-economic analyses.

The data collection covers: i) Selected type and design of biogas co-digestion plants of scale including a) Single farm-size biogas plants, b) Centralized co-digestion biogas plants serving a number of organic farms and organic agro-industries for recycling of organic waste. For point (a) and (b), data from central farm databases are collected from a real energy catchment, where modeling and scenario analyses regarding grass clover based bioenergy production systems are performed. ii) Selected type and design of bio-ethanol production plants. iii) Auxiliary equipment and other inputs applied in alternatives investigated in WP1 to WP4.

Task 5.2 Partial analyses and farm level modeling of bio-energy production systems.

The partial socio-economic and corporate economic analyses and the assessments of environmental and energy balance consequences include sub-tasks for analyzing: i) Grass clover and strip intercropping systems for complement bio-energy production. For the grass clover systems defined, the FarmGHG model will be used to estimate greenhouse gas emissions from the whole farming system, including the bio-energy production systems. This will also include interacting effects on both methane and nitrous oxide emissions (Sommer et al., 2004). The cropping systems will be simulated using the FASSET model to estimate crop production and nitrogen fluxes, including nitrate leaching and nitrous oxide emission for different soil types. ii) Integration of biogas production in organic agriculture. Biogas plants of scale single farm-size plants and large centralised co-digestion plants: a) Based on animal manure producing biogas and nutrients for recycling. b) Based on whey-permeate and grass-clover producing biogas, fodder protein and nutrients for recycling. iii) Integration of centralized bio-ethanol production in organic agriculture. Based on grains, crops and agro-industrial by-products, using bakers yeast and natural enzymes, producing ethanol, fodder protein and nutrients for recycling. iv) Integration of combined centralized bio-ethanol and biogas production in organic agriculture. v) Effect on recycling of nutrients and spread of parasites of integrating biogas and ethanol production in organic agriculture including complementary energy crop production. vi) Effect of integrating biogas and ethanol production in organic agriculture including complementary energy crop production. The tasks involve modification of existing model tools as to consistently handle the multitude of interrelated parameters of the analyses.

Task 5.3 Scenario definition, impact assessments and scenario analyses

Scenario developments are defined in detailed as basis for the analysis. Results from the partial analyses and the data collection form starting points for setting up scenarios for in depth analyses. Promising combinations of the alternatives investigated in partial analyses are combined into alternative scenarios based on multiple criteria. The criteria aim to achieve high combined performances with respect to energy balances, GHG-emission reduction and benign environmental impact, and socio-economic gains. Impact assessments of the grass clover based bioenergy production systems will be carried out in the energy catchment defined, and performed on 1) Single farm types represented in the catchment, 2) Small group of neighbouring farms, 3) a central biogas plant with energy production only, 4) a central biogas plant with biorefinery (crop drying and storage, ethanol production etc.). GIS-maps of the area will be produced, illustrating the potentials for multifunctional energy production. The alternative scenarios cover combined utilization of: i) Complementary bio-energy production in organic agriculture via integration of: a) Centralized bio-ethanol production plants, b) Biogas plants of scale single farm-size plants or centralized co-digestion plants, c) Combined centralized bio-ethanol and co-digestion biogas plants. ii) Strip intercropping systems for complementary biomass production. Balance consequences and the degree of energy integrity within organic agriculture, fossil fuel substitution as well as the overall GHG-emission reduction consequences of deploying the alternatives are important key results in WP5. Sub-tasks include: i) Modification and integration of existing models. ii) Scenario calculations, sensitivity analyses and presentation of key-results. iii) Result interpretation and reporting.

Deliverables:

D5.1 Economic assessment of bio-ethanol and biogas production in organic agriculture. (M 42)

D5.2 Scenarios for bio-energy production in organic agriculture and socio economic analysis. (M 52)
 D5.3 Energy catchment farm database and GIS-map (M38)
 D5.4 Paper submitted on dynamic modelling of the effects of bioenergy production on crop production, nitrate leaching and greenhouse gas emissions (M46)
 D5.5 Paper submitted on the multifunctional role of bioenergy production in organic agriculture. An energy catchment case study (co-deliverable with the DARCOFIII financed project Refugia). (M48)

Milestones:
 M5.1 Method completion and detailed definition of reference and alternative scenarios. (M 28)
 M5.2 Definition of grass clover production systems to be modelled, and Selection of a relevant area for the energy catchment analyses, and definition of the farm data to be required from central databases (M32)
 M5.3 Completion of model tools developments in accordance with desired level of description. This includes adapting of the FarmGHG and the FASSET model to the grass clover systems defined (M 36)
 M5.4 Completion of data collection for partial analysis of corporate and socio-economy of biogas production within organic agriculture. (M 34)
 M5.5 Completion of data collection for partial analysis of corporate and socio-economy of bio-ethanol production within organic agriculture. (M 38)
 M5.6 Results on: Partial analysis of economy of biogas production within organic agriculture. (M 40)
 M5.7 Results on: Partial analysis of economy of bio-ethanol production within organic agriculture. (M 38)
 M5.8 Results on: Analysis of economy of combined bio-ethanol and biogas production within organic agriculture. (M 40)
 M5.9 Model results on crop production, nitrate leaching and greenhouse gas emissions from the grass clover energy production systems defined (M 44)
 M5.10 Results on the multifunctional role of bioenergy production in the energy catchment (M 46)
 M5.11 Model results on: Scenarios for bio-energy production in organic agriculture and socio economic analysis. (M 50)

WP No.: 6 Coordination

	Start date or starting event: January 2007								
Partner id.	Risø								
Person-months per participant	0.8 VIP								
Total PM:	0.8 VIP								

Objectives:
 Co-ordination of the research activities and dissemination of results.

Description of work:

Task 6.1. Co-ordinating activities
 Arrangement of annual project meetings, including the participation of professional from the biogas sector (see A.3) and of meetings in the project steering committee (PSC) consisting of the WP leaders (see A.3). Collating the inputs, synthesizing and writing the annual reports.

Task 6.2 Dissemination of results
 The WP will be responsible for the strategy of dissemination of result. The DARCOF website will be used for dissemination on the internet and for other purposes.

Deliverables:

D6.1 Annual reports (M13, M26, M37, M48)

D6.2 Popular articles for farmers magazines, DARCOF E-news etc. (7 year⁻¹, M12, M24, M36, M48)

Milestones:

M6.1 Annual project meetings (M3, M11, M23, M35, M45)

A.3 Project resources and budget overview

Risø National Laboratory is the national Danish institute for energy research. Risø has strong competences within the area of renewable and sustainable energy research, including bioenergy and systems analysis of energy systems and use. 1. January 2004 RISØ established a interdisciplinary initiative: “Biomass for energy and materials”, with scientists covering the areas of agronomy, crop ecology, nutrient cycling in agriculture, plant genetics, emission of GHG and nutrients to the environment, bioenergy production (process understanding, improvement and up-scaling) from organic wastes, by-products and energy crops, technology forecasting, life cycle analysis, socioeconomic analysis, materials and polymer sciences. Scientists from this interdisciplinary initiative has jointly formulated this project in collaboration with scientists from the National Environmental Research Institute (NERI), Danish Technical University, Danish Institute of Agricultural Science and The Royal Veterinary and Agricultural University (KVL).

NERI undertakes scientific consultancy work, monitoring of nature and the environment as well as applied and strategic research . A range of projects has focused on OA on all levels; from basic ecology in situ to the societal aspects of implementing OA. The Environmental Chemistry and Microbiology Department has strong competences within environmental microbiology required to determine whether recycling of remains from bioenergy production has negative effects on the soil quality/fertility other than effects which may be related to a potential lower amount of easy decomposable carbon being recycled. NERI will be able to determine a series of parameters (soil physical, soil microbiota and soil fauna).

DTU have long term competences in research related to biogasification and will assist with a series of biogasification test of different raw materials.

KVL (Center for Parasitology) have strong competences with animal parasites and is considered strongest Danish partner for determining effects of pre-treatment and biogasification on animal parasites, some of which can be considered as indicator organism.

Project management and interaction with professionals

The project will be managed by a project steering committee (PSC) consisting of the coordinator and the WP-leaders. The board will meet twice a year (at the annual meeting and during summer).

The project will establish a group of professionals from the biogas business for discussion with the consortium of the research direction and relevance. The group consist at this stage of:

- Organic farmer: Hans Ole Jørgensen, Holsted, Phone: 75391275, Fax: 75391274, email: skovbaek@mail.mira.dk (farm plant for biogas).
- Manager of biogas plant: Erik Lundsgaard, Hashøj, Phone: 20222179, fax: 58188027, email: erik.lundsgaard@adr.dk (coordinated medium-scale plant with 20 farmers, mainly pig producers).
- Sales manager Henrik Vestergaard Laursen, Xergi A/S (owned by Hedeselskabet and Schouw and Co, Niels Pedersens Alle 2, 8830 Tjele. Phone: 99351600. hvl@xergi.com
- Chief consultant Bruno Sander Nielsen, The Agricultural Council and the Organisation of Biogas Producers. Axelborg, Axeltorv 3, 1609 København V, Phone: 3339 4267, bsn@landbrug.dk

Table for VIP person month allocated on WP's and partners

Partner WP	1 RISØ BIO	2 RISØ SYS	3 NERI	4 DTU	5 KVL	6 DIAS JBT	7 DIAS AGRO	Total
WP1	56			1.6		14.5		72.1
WP2	25							25
WP3			35		4			39
WP4	32							32
WP5		13.8					11.3	25.1
WP6	0.8							0.8
Total	113.8	13.8	35	1.6	4	14.5	11.3	194

Table for breakdown of total budget on partners and different cost categories (DKK)

Participating institution	Responsible scientist	Salaries		Equip-ment	Operational expenses	Total budget DKK
		Acade-mic	Techn. adm.			
RISØ	ES Jensen	7120544	1228276	50000	726697	9125517
NERI	A Johansen	1970071	0	0	171600	2141671
DIAS	T Dalgaard	1461392	410096	84360	149724	2105572
KVL	A Roepstoeff	190200	168000	0	24000	382200
DTU	J Ejbye Smith	66840	160200	0	18000	245040

A.4. Dissemination of scientific results

- **Planned education of scientists including Ph.D. and post-docs**

In the project we plan to educate two Ph.D. students within WP1 concerning co-production of biogas and bioethanol from organic raw materials. One ph.d.-project will be carried out partly at Risø and partly at DTU. We apply for 2/3 of this Ph.D. scholarship, since we plan to apply for the last 1/3 from DTU or from SOAR. October 2006: SOAR will fund the 1/3 ph.d. scholarship. The second Ph.D. student will primarily work at Dept. of Agricultural Engineering, Danish Institute of Agricultural Sciences, who will apply half of the funding for this Ph.D. The remaining half is funded by the project. Both Ph.d.students will be connected to SOAR. One post.doc. will be associated with the WP4 having expertise within the research field. We plan to have both master and bachelor projects connected with the project from KVL, DTU and other universities.

- **Stays abroad**

Anders Johansen (NERI) has an agreement with Dr. Graham Sparling, at the Landcare Research institution at the University of Waikato, Hamilton, New Zealand, to visit his laboratory for 6 month and apply especially the catabolic response approach on soils that has been treated like scheduled in our project. The laboratory has a great experience on soil quality evaluation by using a broad range of indicators. The travelling expenses is not covered by Bioconcens and the stay is dependent on additional financing.

- **Communication of results. Publication strategy, contributions to national or international workshops etc.**

The publication strategy is to publish the results in international journals with a referee system and also to communicate to the results in popular magazines for farmers and the bioenergy community in Denmark and abroad in collaboration with the DARCOF secretariat. Results will be presented at Danish and international conferences.

A.5. Scientific collaborations

- **Collaboration with other research institutes**

The consortium has strong links with national research institutes within research on bioenergy, e.g. Risø is part of the “Danish Centre for Biofuels” and also associated with the new established “Knowledge-centre for animal manure and biomass technology” at Danish Institute of Agricultural Sciences. The consortium collaborates with international research groups in international (EU) projects on bioenergy production, research in organic plant production, etc. The consortium collaborates with Danish and international companies within bioenergy, e.g. Elsam Biosystems on the up scaling of bioethanol from starch and lignocellulosic materials. The consortium is involved in two EU projects on grain legumes and intercropping in organic farming.

Danish Energy Research Programmes have supported development and demonstration of the biogas technology for almost 20 years. As part of an evaluation of results from these programmes Risø National Laboratory/Lars Henrik Nielsen in collaboration with the Danish Research Institute of Food Economics (FOI) and the Biogas consultant Højme Teknik carried out an extended socio-economic analysis of the utilisation of centralised biogas co-digestion plants in Denmark. This work is published in the report: Nielsen, L.H.; Hjort-Gregersen, K.; Thygesen, P.; Christensen, J., (Socio-economic analysis of centralised Biogas Plants – with technical and corporate economic analysis. In Danish.). Samfundsøkonomiske analyser af biogasfællesanlæg - med tekniske og selskabsøkonomiske baggrundsanalyser. (Fødevareøkonomisk Institut, Frederiksberg, 2002) (Fødevareøkonomisk Institut, rapport nr. 136) 130 p.

- **Co-ordination with other projects**

The project plan is to use data from the longterm DARCOF rotational experiments for the socio-economic analysis (WP5).

Research on bioethanol will be coordinated with the EU-FP5 project Biofuels on bioethanol production from straw and related projects all carried out at Risø.

Results of the extended socio-economic analysis of Danish biogas production were encouraging, and the Danish biogas experience is presently being disseminated at the EU-level via the follow-up EU-ALTERNER project titled ProBiogas (Promotion of Biogas for Electricity and Heat Production in EU Countries. Economic and Environmental Benefits of Biogas from Centralised Co-digestion). This ongoing project is a collaboration between SDU, FOI, Risø, DIAS and the European partners Solagro (France), CRES (Greece), ISA (Portugal), Novem (TheNetherlands), UB (Spain), MOG (Ireland), and ValBiom (Belgium). The project will also benefit from HBMs participation in the EU FP6 project: European Biogas Initiative to improve the yield of agricultural biogas plants (EU-AGRO-BIOGAS).

Interdisciplinary project -Climaite (www.climaite.dk) - with focus on climate-change effects on processes in terrestrial ecosystems. Risø is responsible for project-coordination and is heading project activities on GHG emissions and nitrate leaching. Per Ambus (Risø) is member of COST856 steering committee of Cost-action on "Ecological Aspects of Denitrification, with Emphasis on Agriculture" Per Ambus (Risø) is project leader on national project examining N-dynamic and nitrous oxide emissions in organic grass-clover pastures. Activities in WP4, in particular WP4.1 trace gas emissions in crop rotations, are closely coordinated with similar tasks within the DARCOF project CROPSYS in which Per Ambus participates.

The project has also contact to a group of organic farmers in the Esbjerg Region, via Berg Consulting, who wants to investigate the possibility to establish biogas plants for animal manure and crops. Similarly, the project has link with Michael Tersbøl, Skejby who is initiating a project on energy crop production in organic farming.

A.6 Other issues

Only enzymes produced by natural processes will be used in the project.

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A.8 Curriculum vitae

Curriculum Vitae for Erik Steen Jensen (Coordinator)

Personal data:

Name: Erik Steen Jensen
Born: 29 May 1955

Education:

M.Sc. agronomy (1980), Ph.D plant physiology/nutrition (1986) and D.Sc. plant and soil science (1997) from The Royal Veterinary and Agricultural University of Copenhagen.

Present position (since 1998):

Acting head research programme, Biomass for energy and materials, Plant Research Department, Risø National Laboratory, DK-4000 Roskilde, Phone: +4546774108, Fax: +4546774260, E-mail: erik.s.jensen@risoe.dk

Previous positions:

Aug. 1998-July 2003 - Professor, Plant production in Organic Agriculture, Department of Agricultural Sciences, The Royal Veterinary and Agricultural University, Denmark Oct. 91-Aug. 98 - Senior scientist, Head of research group on: Nitrogen and soil organic matter turnover in agro-ecosystems, Plant Biology and Biogeochemistry Department, Risø National Laboratory. DK-4000 Roskilde. Aug 80 – Oct. 91 Scientist at Risø National Laboratory

Research activities and interests:

Biomass for energy and materials, plant production and energy production in organic farming systems, symbiotic nitrogen fixation, intercropping, nitrogen and soil organic matter turnover in agro-ecosystems with special emphasis on crop residues, farmyard manure, organic waste, *Rhizobium* ecology, stable isotope methodology. Supervisor for 13 completed M.Sc. and 14 completed Ph.D projects.

Research management

25 years (12 years within organic farming research) of experience within research on sustainable plant production, nitrogen and cycling in agriculture and crop diversification. Significant experience as coordinator for Danish and international interdisciplinary and multi-institutional research projects within organic agriculture and environmental issues in agriculture.

Publications and teaching:

82 research papers in international journals with a referee system
75 research papers in books and proceedings
60 popular papers, reports and theses.

Scientific appointments and prizes:

IAEA/FAO expert on the use of stable isotopes in agricultural and environmental research.
Former member of SJVF, Board of Danish Research Centre for Organic Farming and Board of Danish Institute of Agricultural Sciences.
International reviewer for research programmes within organic agriculture.
The Swedish Bertebo Price 2003 for research contributions within organic agricultural research.

Five relevant and recent publications

Andersen M. K., Hauggaard-Nielsen H., Ambus P. and **Jensen E.S.** 2004. Biomass production, symbiotic nitrogen fixation and inorganic N use in dual and tri-component annual intercrops. *Plant and Soil* 266, 273-287.
Jensen, E.S. and Hauggaard-Nielsen, H. 2003. How can increased use of biological N₂ fixation in agriculture benefit the environment? *Plant and Soil* 252, 177-186.
Knudsen, M.T, Hauggaard-Nielsen, H. **Jensen, E.S.** 2005. Pea, faba bean and lupin intercropped with spring barley – performance and N₂ fixation at two temperate locations. *Journal of Agricultural Science* (in press)
Sørensen, P. and **Jensen, E.S.** 1994. Mineralization of carbon and nitrogen from fresh and anaerobically stored sheep manure in soils with different texture. *Biology and Fertility of Soils* 19: 29-35.
Vinther, F.P and **Jensen, E.S.** 2000. Estimating legume N₂ fixation in grass-clover mixtures of grazed organic cropping systems using two ¹⁵N methods. *Agriculture, Ecosystems and Environment* 78, 139-147.

CV for Dr. Anne Belinda Thomsen (Manager of WP1)

Personal data

Name: Anne Belinda Thomsen
Born: 12.12.1961

Education:

Chemical Engineer, B. Sc. 1985, Danish Technical University Ph.D. 1998 Ålborg University.

Present position:

Senior research scientist, Biosystems Department, Risø National Laboratory, Frederiksborgvej 399, DK-4000 Roskilde. Phone: +4547774164; Fax +4546774122, e-mail: Anne.Belinda.Thomsen@risoe.dk

Previous positions:

1 March 1985, assistant lecturer, Danish Academy of Engineering. 1 April 1998 Research scientist, Risø National Laboratory, Environmental Science and Technology Department. September 1998, Senior Scientist, Risø National Laboratory, Plant biology and Biogeochemistry Department.

Research activities and interest:

Research activities are focus on utilisation of biomass to value-added products with main interest within bioenergy in form of bioethanol and biogas. Pretreatment and characterisation of fermentable sugars and products and yields are key research area. ABT has been responsible scientist from Risø in major long-term research activities developing the Danish bioethanol-biogas concept (funded by Energistyrelsen) for which she received the Hede-Nielsen ward of 400.000 Dkr. in 2001. ABT is responsible scientist of ethanol research in two major EU-project (IBUS and TIME) in which co-production of electricity, bioethanol and animal fodder (protein (IBUS) and bioethanol and enzymes (TIME) are the main activities. Supervisor for 1-2 ph.d. students and 1-3 master/bachelor students pr. year. Alternative member of IEA - Conversion of Biomass.

Publications:

32 research papers in international journals with referee systems.

30 research papers in proceedings.

2 research papers as books chapter with a referee systems.

Several research reports.

5 popular papers

3 patents

Five most relevant publications:

Lissen G., **Thomsen AB.**, De Baere L., Verstrate W., Ahring BK (2004) Thermal wet oxidation improves anaerobic biodegradability of raw and digested biowaste. *Environmental Science and Technology* 38 (12): 3418-3424.

Lissen G., Klinke H., Verstrate W., Ahring B., **Thomsen A.B.** (2004) Wet oxidation of organic household waste enriched with wheat straw for simultaneous saccharification and fermentation into ethanol. *Environmental Technologies* 25, 647-655.

Varga E., Klinke H., Recey K., **Thomsen A.B.** High solid simultaneous saccharification and fermentation of wet oxidised corn stover to ethanol. *Biotechnology and Bioengineering* 88,567-574.

Thomsen, AB, Klinke HB. Fermentation media comprising wastewater and use hereof for bioenergy products. PA 2003 00839.

Ahring, B.K., **Thomsen A.B.** A method for processing lignocellulosic materials (to bioethanol and biogas). PA 2000 00427.

Thomsen, A.B., A.B. Olesen, T. Fernqvist, A. Plöger & A.S. Schmidt. (1996) Pretreatment of Wheat Straw using combined Wet Oxidation and Alkaline Hydrolysis Resulting in Convertible Cellulose and Hemicellulose. *Biotechnol. Bioeng.* 49, 568-577

CV for Henrik Hauggaard-Nielsen (Manager of WP2)

Personal data:

Name: Henrik Hauggaard-Nielsen
Born: 28 July 1968

Education:

M.Sc. (1997), PhD (2001) from The Royal Veterinary and Agricultural University of Copenhagen.

Present position: (Since August 2003)

Scientist, Biosystems Department, Risø National Laboratory, Frederiksborgvej 399, DK-4000 Roskilde. Phone: +45 4677 4113, Fax: +45 4677 4260, e-mail: Henrik.Hauggaard-nielsen@risoe.dk

Previous positions:

Feb 01-Jul. 03. Assistant Professor, Organic Farming, Department of Agricultural Sciences, The Royal Veterinary and Agricultural University, DK-2630 Taastrup. Jan. 98-Jan. 01. PhD-student, Plant Biology and Biogeochemistry Department, Risø National Laboratory. DK-4000 Roskilde. May 97-Dec. 97. Research Assistant, Plant Nutrition and Soil Fertility, Department of Agricultural Sciences, The Royal Veterinary and Agricultural University, DK-2630 Taastrup

Research activities and interests:

My research is focused on growing two or more species on the same area of land (intercropping). Of particular interest are competitive interactions between intercropped components according to environmental factors, synchronisation between mineralization-immobilization turnover and plant N uptake from different soil layers and crop residue management and improvement in nutrient conservation by the agro-ecosystem. Supervisor for 2 B.Sc and 7 M.Sc projects

Publications:

12 research papers in international journals with a referee system
1 research paper as a book chapter with a referee system
16 research papers in proceedings
12 popular papers in Danish and 4 in English

Five most relevant publications:

- Hauggaard-Nielsen, H.;** Jensen, E. (2005) Facilitative root interactions in intercrops. *Plant and Soil* (in press)
- Andersen, M K, **Hauggaard-Nielsen, H**, Ambus, P and Jensen, E S (2004) Biomass production, symbiotic nitrogen fixation and inorganic N use in dual and tri-component annual intercrops. *Plant and Soil* 266, 273-287
- de Neergaard, A, **Hauggaard-Nielsen, H**, Jensen, L S and Magid J (2002) Decomposition of white clover (*Trifolium repens*) and ryegrass (*Lolium perenne*) components: C and N dynamics simulated with the DAISY soil organic matter submodel. *European Journal of Agronomy* 16: 43-55.
- Hauggaard-Nielsen, H**, Ambus, P and Jensen, E S (2001) Temporal and spatial root distribution and competition for nitrogen in pea-barley intercropping – a field study employing 32P methodology. *Plant and Soil* 236:63-74.
- Hauggaard-Nielsen, H**, de Neergaard, A., Jensen, L S, Høgh-Jensen, H and Magid, J (1998) A field study of nitrogen dynamics and spring barley growth as affected by the quality of incorporated residues from white clover and ryegrass. *Plant and Soil* 203, 91–101.

CV for Anders Johansen (Manager of WP3)

Personal data:

Name: Anders Johansen
Born: 10th August 1956

Education:

M.Sc. (1988), Ph.D. (1992) from University of Copenhagen.

Present position: (Since August 2002)

Project Senior Scientist, Department of Environmental Chemistry and Microbiology, National Environmental Research Institute, Frederiksborgvej 399, DK-4000 Roskilde. Phone: +45 4630 1316, Fax: +45 4630 1216, e-mail: ajo@dmu.dk

Previous positions:

2002-present Project Senior Scientist, National Environmental Research Institute in Denmark; 2001-02 Unemployed; 2001-01 Project Senior Scientist, National Environmental Research Institute in Denmark; 2000-01 my own private firm (BICO) and part-time teaching (Basic Genetics) at Royal Agricultural University in Copenhagen; 1997-2000 Associate Professor, Royal Agricultural University in Copenhagen; 1995-97 my own private firm (BICO); 1994-05 visiting Post Doc, University in Lund (Sweden); 1992-94 Post Doc, Risø National Research Laboratory; 1992 Ph.D., University of Copenhagen; 1988 M.Sc. (biology), University of Copenhagen.

Research activities and interests:

Main research interests are soil microbial ecology and plant-microbe interactions. This includes: fungal ecology (mycorrhizal fungi) and their role in plant N and P acquisition; microbial antagonists and their effects on phytopathogenic fungi as well as non-target microorganisms and their activity; effects of GMPs on microbial ecology; microbial volatiles (MVOCs) as a tool to characterise growth, metabolic activity and interactions (e.g. as semiochemicals). Educational activities: teaching at courses in genetics and soil microbiology and supervision of M.Sc. students at the Agricultural University in Copenhagen and National Environmental Research Institute.

Publications:

18 research papers in international journals with a referee system; 10 research papers as poster/proceeding; 1 popular paper in Danish.

Five most relevant publications:

- Johansen, A.** and Jensen, E.S. (1996) Transfer of N and P from intact or decomposing roots of pea to barley interconnected by an arbuscular mycorrhizal fungus. *Soil Biology and Biochemistry* 28,73-81.
- Johansen, A.** (1999) Depletion of soil mineral N by hyphae of AM fungi associated with roots of *Cucumis sativus* L. *Plant and Soil* 209,119-127.
- Ekelund, F., Olsson, S. and **Johansen A.** (2003) Changes in the succession of protozoan and microbial populations in soil spiked with a range of copper concentrations. *Soil Biology and Biochemistry*. 35,1507-1516.
- Johansen A.** and Olsson S. (2005) Using PLFA technique to study short-term effects of the biological control agent *Pseudomonas fluorescens* DR54 on the microbial population in barley rhizosphere. *Microbial Ecology* (in press).
- Johansen, A.**, Knudsen, I.M.B., Binnerup, S.J., Winding, A., Johansen, J.E., Jensen, L.E., Andersen, K.S., Sørensen, M.M. & Bonde, T.A. (2005) Non-target effects of the microbial control agents *Pseudomonas fluorescens* DR54 and *Clonostachys rosea* IK726 in soils grown with barley followed by sugar beet: a greenhouse assessment. *Soil Biology and Biochemistry* (in press).

Curriculum vitae, for Per Ambus (Manager of WP 4)

Personal data:

Name: Per Ambus
Born: 08.11.1959.

Address

Biosystems Department (BIO-309), Risø National Laboratory, DK-4000 Roskilde.
Tel: (+45) 4677 4152. e-mail: per.ambus@risoe.dk; www: http://www.risoe.dk/pbk/research_uk/ple.htm

Education and positions

M.Sc. (1987) in General Microbiology at Cphg Univ; Ph.D. (1992) on nitrogen dynamics in riparian areas (Cphg Univ.). Participation in training courses in HPLC and ion chromatography, health physics, hazardous waste and radio isotope training, project management and isotope ratio mass spectrometry.

1989 Visiting Graduate. Southeast Watershed Research Laboratory, USDA Georgia, USA.
1991-1993 Postdoctoral Fellow. Department of Population Biology, Copenhagen University.
1993-1994 Research Scientist. Plant Ecosystems and Nutrient Cycling, Plant Biology and Biogeochemistry Department, Risø National Laboratory.
1995-1996 Visiting Research Associate. Kellogg Biological Station, Michigan State University, USA.
1997-date Research Scientist and Senior Research Scientist (1998-date). Plant Ecosystems and Nutrient Cycling, Plant Biology and Biogeochemistry Department, Risø National Laboratory.

Research activities

Focus of my research has been on biogeochemical cycling of C and N in soil-plant ecosystems, including studies at the laboratory scale and in large scale field experiments. In particular issues of plant residue decomposition and greenhouse gas emissions from soils have been investigated. Since 1998 I have been responsible for the stable isotope laboratory at Risø, and has participated in development and application of novel stable isotope techniques. I have participated as PI in several EU-projects (STEP; Nofretete; GreenGrass) as well as national projects. Coordinator of national project on greenhouse gas emissions from grass pastures (DINOG). Experience in teaching and supervising at graduate and post-graduate levels. Currently external advisor for one Ph.D. student.

Publications

I have published 110 publications of which 35 are printed in international, peer reviewed journals.

Five recent publications

Ambus, P. 2005 Gross nitrogen turnover and nitrous oxide emission in organic grass-clover pastures. Nutrient Cycling in Agroecosystems. In press
Andersen, M.K., Hauggaard-Nielsen, H., **Ambus, P.** and Jensen, E.S. 2005. Biomass production, symbiotic nitrogen fixation and inorganic N use in dual and tri-component annual intercrops. *Plant and Soil*. 266: 273-287.
Formánek, P. and **Ambus, P.** 2004. Assessing the use of $\delta^{13}\text{C}$ natural abundance in separation of root and microbial respiration in a Danish beech (*Fagus sylvatica* L.) forest. *Rapid Communications in Mass Spectrometry*. 18: 1-6.
Grogan, P., Michelsen, A., **Ambus, P.** and Jonasson, S. 2004 Effects of differing freeze-thaw regimes on nutrient cycling and respiration in sub-arctic heath tundra. *Soil Biology and Biochemistry*. In press Jan 2004.
Pilegaard, K., Mikkelsen, T.N., Beier, C., Jensen, N.O., **Ambus, P.**, and Ro-Poulsen, H. 2003. Field measurements of atmosphere-biosphere interactions in a Danish beech forest. *Boreal Environment Research*. 8: 315-333.
ence of crop residue particle size, quality and placement. *Phyton*, 41(3): 7-15.

Curriculum vitae for Lars Henrik Nielsen (Manager of WP 5)

Personal data:

Name: Lars Henrik Nielsen

Born: 12. July 1949

Address

Systems Analysis Department, Risø National Laboratory, P.O.Box 49, DK-4000 Roskilde, Denmark.

Phone: +45 4677 5110 (direct) Fax.: +45 4677 5199 [Email: lh.nielsen@risoe.dk](mailto:lh.nielsen@risoe.dk), <http://www.risoe.dk>

Education and positions

University of Copenhagen, Niels Bohr Institute. Master of science: Physics and mathematics. Specialization in: Solid state physics and energy physics (1981). 1981-83 Candidate scholarship at the Energy Systems Group, Risø. Subject: Planning under uncertainty. Method and model development. Main report: Inclusion of uncertainty in economic assessments of energy technologies. 1983-1992 Position as Research Scientist at Energy Systems Group, Risø. 1992- Senior Scientist in the field of energy system analysis.

Research activities

Energy and environmental planning. Development and analysis of long term energy and environmental scenarios. Planning under uncertainty. Technical-economic modelling and assessment. Modelling and simulation of power and heat supply systems. System integration of new and renewable energy technologies, incl. hydrogen technology.

Five recent and relevant publications

- Nielsen, L.H.;** Hjort-Gregersen, K., 2004. Greenhouse gas emission reduction via centralised biogas co-digestion plants in Denmark. In: Proceedings. International conference: Greenhouse gas emissions from agriculture - mitigation options and strategies, Leipzig (DE), 10-12 Feb 2004. Weiske, A. (ed.), (Institute for Energy and Environment, Leipzig, 2004) p. 183-189
- Nielsen, L.H.;** Hjort-Gregersen, K., 2002. Socio-economic analysis of centralised biogas plants. In: Proceedings CD-ROM. 12. European biomass conference, Amsterdam (NL), 17-21 Jun 2002. (WIP-Munich, Munich, 2002) p. 1313-1316
- Nielsen, L.H.;** Hjort-Gregersen, K.; Thygesen, P.; Christensen, J., 2002. (Socio-economic analysis of centralised Biogas Plants – with technical and corporate economic analysis. In Danish.). Samfundsøkonomiske analyser af biogasfællesanlæg - med tekniske og selskabsøkonomiske baggrundsanalyser. (Fødevareøkonomisk Institut, Frederiksberg, 2002) (Fødevareøkonomisk Institut, rapport nr. 136) 130 p.
- Petersen, A.H.; Juhl, C.; Pedersen, T.E.; Ravn, H.; Søndergren, C.; Simonsen, P.; Jørgensen, K.; **Nielsen, L.H.;** Larsen, H.V.; Morthorst, P.E.; Schleisner, L.; Sørensen, F.; Sørensen, B., 2001. Hydrogen as an energy carrier - scenario analyses. (In Danish). Danish title: Scenarier for samlet udnyttelse af brint som energibærer i Danmarks fremtidige energisystem. Slutrapport. IMFUFA-Tekst-390 (2001) 226 p.
- Nielsen, L.H.;** Jørgensen K., 2000. Electric vehicles and renewable energy in the transport sector - energy system consequences. Main focus: Battery electric vehicles and hydrogen based fuel cell vehicles. Risø-R-1187(EN) (2000) 80 p.

CV for Jens Ejbye Schmidt (Contributor WP1)

Personal data:

Name: Jens Ejbye Schmidt
Born: 20 May 1965

Education:

M.Sc. (1990), PhD (1994) from Department of Biotechnology, The Technical University of Denmark.

Present position: (Since 2001)

Associate Professor, Environment & Resources, The Technical University of Denmark (DTU), Bygningstorvet, building 115, DK-2800 Kongens Lyngby, Phone: +45 45251429, Fax: +45 45932850, e-mail: jes@er.dtu.dk

Previous positions:

1998-2000. Associate Professor at Department of Applied Chemistry and Department of Biotechnology, DTU.
1998. Associate Professor at Department of Biotechnology, DTU.
1996-1997;1994-1995 Assistant Research Professor at Department of Environmental Science and Engineering, DTU.
1991-1993. PhD-student at Department of Biotechnology, DTU.
1990-1991. Research Assistant Wadsworth Center for Laboratories and Research, New York State, Department of Health and Department of Biomedical Sciences, School of Public Health, State University of New York at Albany, Albany, NY, USA.

Research activities and interests:

The research of Jens Ejbye Schmidt is focused on obtaining knowledge about biotechnological processes that have relevance to microbial treatment of contaminated air, wastewater, solid waste and soil. His research fields include the following main areas: Micro organisms and their potential and limitations for environmental purposes; principle of aerobic and especially anaerobic microbial conversion; design of cultures for specific clean-up purposes; bacterial characterization, the biogas process and the microbiology of anaerobic degradation of organic matter, production of biofuels from waste, removal of xenobiotics, anaerobic waste water treatment; modeling of anaerobic processes, sensors and biosensors. JES has been Danish coordinator in the previous EU-project (FLEXIBLE) under the fourth frame program (Brite- Euram) and currently project coordinator on the project BIOWASTE, Treatment of sewage sludge for safe disposal on agricultural land (see www.biowaste.dk) under the fifth frame program.

Publications:

Jens Ejbye Schmidt has more than 80 scientific publications scientific papers, book chapters and conference proceedings within the area of environmental biotechnology.

Five most relevant publications:

Hansen,T.L., **Schmidt,J.E.**, Angelidaki,I., Marca,E., Jansen,J.I.C., Mosbæk,H. & Christensen,T.H. (2004): Method for determination of methane potentials of solid organic waste. *Waste Management*, **24**, 393-400. (Virtual Journal of Environmental Sustainability, vol. 2, Issue 5, 2004).

Batstone,D.J., Torrijos,M., Ruiz,C. & **Schmidt,J.E.** (2004): Use of an anaerobic sequencing batch reactor for parameter optimisation in modelling of anaerobic digestion. *Water Science and Technology*, **50**, (10), 295-303.

Schmidt,J.E., Batstone,D.J. & Angelidaki,I. (2004): Improved nitrogen removal in upflow anaerobic sludge blanket (UASB) reactors by incorporation of Anammox bacteria into the granular sludge. *Water Science and Technology*, **49**, (11-12), 69-76.

Hansen,T.L., Svärd,Å., Angelidaki,I., **Schmidt,J.E.**, Jansen,J.I.C. & Christensen,T.H. (2003): Chemical characteristics and methane potential of source-separated and pre-treated organic municipal solid waste. *Water Science and Technology*, **48**, (4), 205-208.

Schmidt,J.E., Angelidaki,I., Christensen,N., Batstone,D.J., Lyberatos,G., Stamatelatos,K., Lichtfouse,E., Elbisser,B., Rogers,K., Sappin-Didier,V., Denaix,L., Metzger,L., Borghi,V. & Montcada,E. (2003): Biowaste - a new European project. Bioprocessing of sewage sludge for safe recycling on agricultural land - BIOWASTE. *European Association of Chemistry and the Environment Newsletter*, (5), 1-6.

Curriculum vitae of Allan Roepstorff (Contributor WP 3)

Personal data

Name: Allan Roepstorff
Date of birth: 16 August 1950

Education

Dr. Med.Vet., Ph.D., M.Sc.(biology)

Present positions:

Deputy Director (1993-), Danish Centre for Experimental Parasitology (DCEP), Department of Pathobiology, The Royal Veterinary and Agricultural University, Dyrøløgevej 100, DK-1870 Frederiksberg C, phone +45 3528 2746, fax +45 3528 2774, e-mail aro@kvl.dk

Previous positions

Associate Professor at The Danish Centre for Experimental Parasitology, Dept. Veterinary Pathobiology (parasitology) since 1994

Senior Research Fellow at Dept. Veterinary Microbiology (swine helminths) 1991-1994.

Post-doctoral Fellow at The Technical University of Denmark 1990-91 (fish parasites).

Post-doctoral Fellow at Dept. Veterinary Microbiology 1990-91 (parasites of organic swine)

Post-doctoral Fellow (swine parasites) at Dept. Veterinary Microbiology, KVL, 1985-89.

Ph.D.scholarship (swine parasites) at Department of Clinical Studies, KVL, 1983-1985.

Research areas

The main research interests are population biology, ecology, epidemiology, host-parasite relationship, and sustainable control of helminth (*Ascaris*, *Oesophagostomum*, *Trichuris*) and coccidia infections of domestic animals (primarily swine). Daily head of the *Ascaris/Trichuris* research group.

Teaching

Teaching of veterinary students, B.Sc.and M.Sc. students.

Supervision 1994-2004: 8 MSc students, 10 PhD students, and 1 Marie Curie post doc.

Coordinator of 'Parasitological Methods', a course at the international M.Sc. education in parasitology.

Coordinator of 'Ecology of Parasites', a course at the international M.Sc. education in parasitology.

Coordinator of the NorFA Ph.D. course: 'Graduate course in Advanced Veterinary Parasitology: Epidemiology and sustainable control of parasites in pigs, poultry, and horses' 2004

Publications

Author and co-author of 77 publications in international peer reviewed journals, 3 publications in Danish journals with referees, 30 book chapters, manuals, and scientific reports, 35 informative publications for farmers, 102 abstracted congress presentations, 1 Ph.D.Thesis, and 1 Doctoral Thesis.

Five selected publications

Roepstorff,A. (2003). *Ascaris suum* in pigs: Population Biology and Epidemiology. Doctoral Thesis. Danish Centre for Experimental Parasitology, The Royal Veterinary and Agricultural University, Copenhagen, Denmark. 112 pp.

Petkevičius,S., Murrell,K.D., Bach Knudsen,K.E., Jørgensen,H., **Roepstorff,A.**, Laue,A., Wachmann,H. (2004). Effects of short-chain fatty acids and lactic acids on survival of *Oesophagostomum dentatum* in pigs. *Veterinary Parasitology* 122, 293-301.

Steenhard,N.R., Jensen,T.K., Baggesen,D.L., **Roepstorff,A.**, Møller,K. (2002). Enhanced faecal excretion and mucosal persistence of *Salmonella* Typhimurium in pigs subclinically infected with *Oesophagostomum* spp.. *American Journal of Veterinary Research* 63, 130-136

Roepstorff,A., Nilsson,O., Oksanen,A., Gjerde,B., Richter,S.H., Örtenberg,E., Christensson,D., Martinsson,K.B., Bartlett,P.C., Nansen,P., Eriksen,L., Helle,O., Nikander,S., Larsen,K. (1998). Intestinal parasites in swine in the Nordic countries: prevalence and geographical distribution. *Veterinary Parasitology* 76, 305-319.

Roepstorff,A., Eriksen,L., Slotved,H.-C., Nansen,P. (1997). Experimental *Ascaris suum* infection in the pig: worm population kinetics following single inoculations with three doses of infective eggs. *Parasitology* 115, 443-452.

CV for Mette Hedegaard Thomsen (Contributor WP1)

Personal data:

Name: Mette Hedegaard Thomsen
Born: 28 March 1973

Education:

M.Sc. (2000) from Aalborg University, Esbjerg, PhD (2004) from University of Southern Denmark, Esbjerg.

Present position: (Since January 2004)

Scientist, Biosystems Department, Risø National Laboratory, Frederiksborgvej 399, DK-4000 Roskilde. Phone: +45 4677 4223, Fax: +45 4677 4122, e-mail: mette.hedegaard.thomsen@risoe.dk

Previous positions:

Aug. 00-Feb. 01. Research Assistant, Centre for Agro-Industrial Biotechnology, University of Southern Denmark, Esbjerg.

Research activities and interests:

My research is focused on industrial microbiology, especially on utilisation of waste/side-product from the Danish agro-industry by microbial fermentation. In my PhD-studies a process was developed for lactic acid fermentation of brown juice (heat-treated grass juice) in the green crop-drying factory. The aim of this industrial fermentation process was conversion of brown juice into a stable, storable fermentation medium to be used for *e.g.* L-lysine fermentation. The work was done in co-operation with the company AgroFerm A/S, Esbjerg, who are initiating a Danish L-lysine production based on this lactic acid fermented brown juice. Apr. 02-Jun. 02 I spend three month at Professor Jean-Pierre Guyot, Unité de recherche 106 "Nutrition, Alimentation, Sociétés", Institutes de recherche pour le développement, IRD, Montpellier, France working with enzyme production of amyolytic lactic acid bacteria. In my current position at Risø National Laboratory my work is focused on pre-treatment and fermentation (with yeast and fungi) of renewable materials for the production of bio-ethanol, including characterisation of the nutrients before and after pre-treatment and fermentation mainly by HPLC analysis. I'm currently supervising 3 M.Sc projects.

Publications:

1 research paper in international journals with a referee system
2 submitted papers in international journals with a referee system
1 submitted research paper as a book chapter with a referee system
1 research paper in proceedings
1 popular paper in Danish
3 posters

Five most relevant publications:

Thomsen MH, Bech D, Kiel P (2004) Manufacturing of stabilized Brown Juice for L-lysine production – from University Lab Scale over Pilot Scale to industrial Production, *Chem. Biochem. Eng. Q.* 18 (1), 37-46.

Thomsen MH, Andersen M, Kiel P (2005) Use of Plant Juice as Fermentation Medium. In: *Biorefineries/Biobased Industrial Processes and Products*, Wiley. Submitted.

Thomsen MH. Complex media from processing of agricultural crops for microbial fermentation. Submitted to *Applied Microbiology and Biotechnology*.

Thygesen A, **Thomsen MH**, Jørgensen H, Christensen BH, Thomsen AB (2004) Hydrothermal Treatment of Wheat Straw on Pilot Plant Scale, 2nd World Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, Rome, Italy, May 10-15.

Thomsen MH, Martín C, Taherzadeh M, Hauggaard-Nielsen H, Thomsen A B (2004) Bioethanol Fermentation with *Mucor indicus* on a White Clover/Rye grass Substrate. *Biorefinica 2004, Internationales Symposium Biobasierte Producte und Bioraffinerien*, Osnabrück, Germany, October 27-28.

CV for Henrik B. Møller (Contributor WP1)

Personal data:

Name Henrik B. Møller
Year of birth 1962

Occupation Scientist M.Sc. (Ag.Eng.), Danish Institute of Agricultural Sciences (DIAS)

Education

2003 Ph.D., Danish Technical University, Lyngby
1990 M.Sc., Agronomy, Royal Veterinary and Agricultural University

Employment record

1998-2004 Scientist, Danish Institute of Agricultural Sciences (DIAS), Dept. of Agricultural Engineering, Research Centre Bygholm
1995-1997 NIRAS A/S Consulting Engineers and Planners. Project manager for anaerobic digestion.
1990-1995 Herning Municipal Utilities. In charge of operation of full-scale biogas plant for treatment of liquid manure, organic industrial waste, and organic domestic waste.

Key qualifications

Separation of nutrients and anaerobic digestion of manure. Recycling of nutrients. Greenhousegas emissions.

Selected publications

Hartmann, H., Møller, H.B. & Ahring, B.K., 2004. Efficiency of the anaerobic treatment of the organic fraction of municipal solid waste: collection and pre-treatment. *Waste Manage Res* 22, 35-41.
Sommer, S.G., Petersen S.O. & Møller, H.B., 2004. Algorithms for calculating methane and nitrous oxide emissions from manure management. *Nutrient Cycling in Agroecosystems* 69(2), 143-154.
Møller, H.B., Sommer, S.G., Hansen, M.N., 2004. Heavy metal load from fractions of manure after separation. Submitted to *Bioresource Technology*.
Møller, H.B., Ahring, B.K., Sommer, S.G., 2004. Methane productivity of manure, straw and solid fractions of manure. *Biomass and Bioenergy*, 26, 485-495.
Møller H.B., Sommer, S.G., Ahring, B.K., 2003. Biological degradation processes and greenhouse gas emissions during pre-storage of liquid manure inside buildings. *Journal of Environmental Quality*, 33, 27-36.
Møller, H.B., Sommer, S.G. & Ahring, B.K., 2002. Separation efficiency and particle size distribution in relation to manure type and storage conditions. *Bioresource Technology*, 85, 189-196.
Møller, H.B., Sommer, S.G. & Ahring, B.K., 2002. Separation efficiency and particle size distribution in relation to manure type and storage conditions. *Bioresource Technology*, 85, 189-196.
Sommer, S.G., Søgaard, H.T., Møller, H.B. & Morsing, S., 2001. Ammonia volatilization from sows on grassland. *Atmos. Environ.*, 35, 2023-2032.
Møller, H.B., Lund, I. & Sommer, S.G., 2000. Solid-liquid separation of livestock slurry: efficiency and cost. *Bioresource Technology*, 74, 223-229.
Møller, H.B., Sommer, S.G., Andersen, B.H., 2000. Nitrogen mass balance in deep litter during the pig fattening cycle and during composting. *J. Agr. Sci. Camb.*, 135, 287-296.
Sommer, S.G. & Møller, H.B., 2000. Emission of greenhouse gases during composting of deep litter from pig production - effect of straw content. *J. Agr. Sci. Camb.*, 134, 327-335.

Curriculum vitae Klaus S. H. Skytte (Contributor to WP5)

Personal data

Name: Klaus S. H. Skytte
Date of birth: 21 December 1969.

Education:

Ph.D. in Economics. Thesis on Topics on electricity trade. University of Copenhagen, Ins. of Economics. June 2001. The University of Copenhagen. The Danish cand.scient.oecon. degree. Master's thesis on semidefinite programming. September 1995

Present position

Senior scientist, Systems Analysis Department, P.O. Box 49, DK-4000 Roskilde, +45 4677 5157, klaus.skytte@risoe.dk. At Risø since 1996.

Previous experiences

The University of Paris VII, Denis-Diderot, and the University of Paris I, Panthéon-Sorbonne. D.E.A. de Statistique et Modèles Aléatoires en Economie et Finance. Exchange stay for one year between the University of Copenhagen and the University of Paris. 1993 -1994.

Areas of research :

Economic and mathematical modelling, operations research, energy and environmental modelling, electricity markets, energy planning, microeconomics.

Selected relevant publications:

- Jensen, S.G.; **Skytte, K.** 2003 Simultaneous attainment of energy goals by means of green certificates and emission permits. *Energy Policy* (2003) Vol. 31, pp. 63-71
- Jensen, S.G. and **Skytte, K.** 2002 Interaction between the power and green certificate market. *Energy Policy* Vol. 30, Issue 5, pp. 425-435.
- Skytte, K.** 2000 Fluctuating renewable energy on the power exchange. *The International Energy Experience*, MacKerron & Pearson (Edt), Imperial College Press, p. 219-231.
- Skytte, K.**, 1999 The regulating power market on the Nordic power exchange Nord Pool. An econometric analysis. *Energy Economics* Vol. 21 p. 295-308.
- Skytte, K.**; Jensen, S.G.; Morthorst, P.E.; Olsen, O.J., 2004. Støtte til vedvarende energi? Book in Danish, Jurist- og Økonomforbundets Forlag, København, 182 p.

Curriculum vitae Tommy Dalgaard (Contributor to WP5)

Name, birth Tommy Dalgaard, born December 24, 1970
Education Ph.D. Agroecology. The Royal Veterinary & Agricultural University of Denmark (RVAU).
M.Sc. Agroecology. RVAU, Dept. of Agricultural Sciences.
B.Sc. Agricultural Politics. RVAU, Dept. for Economics and Natural Resources.

Employment Record

Year	Organisation	Position and Responsibilities
1996-	Danish Institute of Agricultural Sciences (DIAS)	Head of Research Unit, Dept. of Agroecology (2004-) Senior Scientist, Dept. of Agric. Systems (2002-2004) Scientist, Dept. of Land Use (1996-2002)
1996	National Inst. of Animal Sci.	Scientific Assistant, Section for Production Systems.
1993	Tureby-Køge Agr. extension	Agronomic Assistant. Field experiments.
1992	Royal Vet. & Agric. University of Denmark (RVAU)	Teacher in botany (1994) Teacher in chemistry (1992-1994)

Key qualifications for the project

TDA has research experience from several Danish and international, inter-disciplinary research projects regarding multifunctional agriculture, GIS-scenario analyses, upscaling methodologies, organic farming and energy utilisation. Is currently WP leader in the EU-FP6 Strategic Research Project on ‘*Impact assessment of multifunctional agriculture*’. (www.mea-scope.org) (2004-2007), activity leader regarding landscape GIS development in the EU-FP6 Integrated Project (IP) Nitro-Europe (www.neu.ceh.ac.uk), and project leader for DIAS’ part of an IP on ‘*Sustainability Impact Assessment of Multifunctional Land Use in European Regions*’. (www.sensor-ip.org) (2005-2008). Is co-initiator of a research network on multifunctional farming funded by The Danish Research Council (SJVF) (2003-2005). Has been invited speaker in context of OECDs working party on organic farming, IPCC/USDA, The Danish Parliaments committee for Nature & Env., EUROSTAT, & EC- research projects, networks & centres of excellences.

Other activities

TDA has served as invited peer reviewer for a number of journals including *Journ. of Env. Quality*, *European Journ. of Agronomy*, *Agriculture Ecosystems and Environment*, *Agricultural Systems*, *China Science Press*, *Journ. of Agric. Education & Extension*, *The ScientificWorld*, *Biological Agriculture & Horticulture*, *Env. & Resource Economics*, *Int. Journ. of Agric. Resources Governance & Ecology*. He has coordinated reviews for int. seminar proceedings, and serves as reviewer for *The UN Millennium Ecosystem Assessment*. Appointed expert for the research syntheses’ regarding organic farming and: 1) Groundwater protection, 2001. 2) Bioenergy, 2004. (www.darcof.dk). Appointed expert for The Danish Action Plan for the Aquatic Env. III (www.vmp3.dk) scientific expert groups on “P flows, losses and amendment measures” and on “Economic models of cost for reduction of nutrient losses” (2004). Approved short-term expert (STE) in the implementation of EU agricultural policies, The Czech Ministry of Agriculture (2004-2005).

Scientific publications – selected references

Has published more than 20 peer reviewed papers, 30 conference contributions and 25 research reports. I.e:
Dalgaard T (2005) *Landscape Agroecology*. Book Review. *Agricultural Systems* 85 203-204.
Dalgaard T, Hutchings NJ and Porter JR (2003) *Agroecology, scaling and interdisciplinarity*. *Agriculture Ecosystems and Environment* 100 39-51. Review paper.
Dalgaard T, Hutchings NJ, Hansen JF and Mikkelsen HE (2003) *Scenarios for multifunctional landscape development - interactions between agriculture, nature and economy*. In: Helmig K & Wiggering H (eds.) *Sustainable Development of Multifunctional Landscapes*. p. 247-256. Springer Verlag.
Dalgaard T, Heidman T and Mogensen L (2002) *Potential N-losses in three scenarios for conversion to organic farming in a local area of Denmark*. *European Journal of Agronomy* 16: 207-221.
Dalgaard T, Halberg N & Porter JR (2001) *A model for fossil energy use in Danish agriculture used to compare organic and conventional farming*. *Agriculture, Ecosystems & Environment* 87(1) 51-65.
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Curriculum vitae Uffe Jørgensen (Contributor to WP5)

Name and birth

Uffe Jørgensen (UJ), born 13.01.1960

Scientific degrees

M.Sc. in horticulture from the Royal Veterinary and Agricultural University (KVL), 1986

Employment record

1987 – 1992 Scientific assistant at the Danish Institute of Plant and Soil Science, Jyndevad Research Station

1992 – 1999 Scientific assistant at the Danish Institute of Plant and Soil Science, Research Centre Foulum

1999 - Senior Scientist at the Danish Institute of Agricultural Sciences, Dept. Agroecology

Key qualifications for the project

UJ has studied non-food crops and energy aspects within agriculture for >10 years with main focus on perennial energy crops such as miscanthus and willow. The works included investigation of genotypic variation and of environmental aspects of energy crop production, especially nitrate leaching. Recently, UJ has measured nitrate leaching from common agricultural crops as well, and participated in the development of an empirical model on nitrate leaching from agriculture. Responsible for the DARCOF synthesis of knowledge on energy in organic farming published in 2004.

Other activities

UJ has coordinated a number of research projects (R) and chaired national (N) and international (I) working groups: Production of annual and perennial energy crops (R), 1993-1997. The non-food group of the Danish Institute of Plant and Soil Science (N), 1994. Agricultural Energy Crops and Residues, Lignocellulosic Solid Fuels under the International Energy Agency (IEA) (I), 1995-1997. Member of the non-food research committee under the Ministry of Agriculture and Fisheries (N), 1995-2001. Topic coordinator at the EU-projects 'European Energy Crops Overview' and 'European Energy Crops InterNetwork' (R, www.eeci.net), 1996-1999. The 'Nitrogen-group' appointed by the ministries of Environment and Agriculture to prepare the 3rd national action plan for the aquatic environment (N), 2003. Development of methods for the monitoring of agricultural environmental impact (R), 2004-2008.

Publications

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Curriculum vitae Jørgen E. Olesen (Contributor to WP5)

Name and birth

Jørgen E. Olesen, born 28.10.1958

Scientific degrees

M.Sc. in agriculture from Royal Veterinary and Agricultural University (KVL)

Employment record

- 1983-1986 Scientist, Danish Institute of Plant and Soil Science, Agrometeorological Service
1986-1991 Head of department, Danish Institute of Plant and Soil Science, Department of Agrometeorology
1991-1993 Scientist, Danish Institute of Plant and Soil Science, Department of Soil Science
1993-1994 Senior researcher, Danish Institute of Agricultural Sciences, Department of Crop Physiology and Soil Science
1994- Head of research group on Crop Production, Department of Crop Physiology and Soil Science, Danish Institute of Agricultural Sciences
2003- Research professor, Department of Agroecology, Danish Institute of Agricultural Sciences

Research areas

He was involved in initiating Danish research on agrometeorology. He has lead several interdisciplinary projects, including projects on integrated wheat production, application of remote sensing and GIS in agriculture, development of a whole-farm simulation model, and several projects on organic farming and reduced tillage. He has participated in six EU projects and concerted actions on the effect of climate change on agriculture and also contributed as an author to the third IPCC assessment report, and is a lead author for the IPCC fourth assessment report. He has participated in two EU projects on mitigation to climate change, and he currently participates in two EU projects (CARBOEUROPE and ENSEMBLES) on adaptation and mitigation to climate change.

Other activities

He is currently co-supervisor of three Ph.D. studies. Key supervisor at the research school for organic farming (SOAR). He participates in COST action 627, where he coordinates WP4 on scenarios and policy implications. He is member of the editorial advisory board of European Journal of Agronomy, and vice-president of the Nordic Association of Agricultural Scientists.

Publications

He has published 62 papers in international scientific journals, 123 papers at conferences and 138 in reports and technical letters.

- Berntsen, J., Jacobsen, B.H., Olesen, J.E., Petersen, B.M. & Hutchings, N.J. (2003). Evaluating nitrogen taxation scenarios using the dynamic whole farm simulation model FASSET. *Agricultural Systems* **76**, 817-839.
Olesen, J.E. & Bindi, M. (2002). Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy* **16**, 239-262.
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Olesen, J.E., Hansen, P.K., Berntsen, J. & Christensen, S. (2004). Simulation of above-ground suppression of competing species and competition tolerance in winter wheat varieties. *Field Crops Research* **89**, 263-280.
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