Extended Project descriptions for Bio-Value SPIR

Project 1: Innovative biomass production systems, harvest and conservation technologies

Updated May 2016

Table of Contents

1 Main ideas and research focus for biomass work in Biovalue

The overall vision is to facilitate development of a diverse and flexible biomass production sector which can supply biorefineries with a wide variety of agricultural crops and crop residues tailored for biorefinery purposes and produced under sustainable conditions, optimising land use and reducing the costs of production and transport. A reliable supply of biomass is a fundamental prerequisite if we are to achieve economic and environmental sustainability in the future biorefineries.

The approach will define new crop production systems and new genotypes designed to increase biomass productivity and resource use efficiency by increasing plant diversity and the duration of the crop growing season. Strong links between fundamental plant research and agricultural innovation will be established. Special efforts will be devoted to new biomass production systems optimized for a more sustainable Danish milk production; hereunder establishment of new multi-purpose cropping systems, in which protein production from green biomass is included. Protein fodder quality in different cropping systems will be evaluated for optimized protein extraction and the variation between cropping systems in terms of quantity, quality and extractability of protein characterized.

In connection with the Mid-Term Report it is found necessary to revise the existing Extended Project Description from July 2014. The description was greatly influenced by the start-up and establishment of testing the first year. The description is reconfigured to draw up a few concrete goals to be achieved and to insert appropriate milestones that relate to the objectives set.

Parts of the activities of the project have evolved and taken a turn and specifically Kongskilde has left the project due to the change in ownership of R&D department into an independent company. This means that the activities envisaged in the development of mechanical equipment for harvesting, storage and transport is no longer included in the project. Knowledge Center for Agriculture (KCA) changed name to SEGES. Moreover, AgroTech switched from being a subsidiary of SEGES to be a new division of Danish Technological Institute (DTI).

Activities undertaken in the overall project will help to illuminate the two value chains selected:

- Green biomass with clover and grass
- Yellow biomass with straw.

2 Objectives

The research objectives are to:

- Increase the quantity and quality of biomass raw materials available for biorefining by development of innovative multi-purpose production systems, embracing annual and perennial plant species. Reorganization of conventional crop rotations, harvest procedures and storage in order to improve biomass production and reduce environmental impacts.
- Achieve basic understanding of key factors controlling the productivity and resource-use efficiency of novel biomass production systems (critical growth stages, plant density, canopy structure, day-length responses, low temperatures, nutrient and water exploitation).
- Exploiting the potential of genotypic differences in wheat varieties. Breeding of new crop genotypes with improved yield and quality of biomass. As an integral part of this, a detailed mapping of the genotypic variation in winter wheat will be made to give dense marker coverage throughout the wheat genomes, thereby creating the basis for genomic selection in future breeding programs.

- Use targeted plant breeding to increase the quantity of harvested biomass per unit agricultural land of cereal crops and perennial grasses.
- Achieve basic understanding of the fundamental interactions between genotype, environment and management factors that can be exploited to sustainably intensify the biomass yield per unit land area and to deliver tailored biomass qualities for biorefineries.
- Testing of protein fodder quality and quantity in green crops (extraction of proteins will be carried out in project 2).
- Optimize land management, logistics for biomass use in biorefining and exploitation of the quantity and quality changes of biomass during storage. Development of new planning tools for harvest, storage and transportation of biomasses to processing plants.
- Develop cost-effective management practices for marginal lands to harvest their biomass potential.

The project activities are planned to facilitate the development of new technologies which ensure cost-effective production and delivery of increased quantities of biomass with optimized quality for biorefinery purposes. This includes technologies for transport and conservation of biomass.

3 Hypotheses for the scientific work

Among genotypes of wheat with similar grain yields, there is a large difference in straw productivity and sugar release. Also, in the so far undeveloped energy crop species, there are genotypes which are much more efficient in converting solar energy and tolerating abiotic stress than others. Breeding and selection may further increase photosynthetic efficiency. Perennial grass systems with low inputs can either be optimized by multi-species mixing which has been shown to increase total yield due to complementarity or by selecting species with efficient photosynthesis. The cell wall composition of grass mixtures can be strongly manipulated by management, including harvest time. There is also a large biomass potential to be harvested from perennial grasses and grass-clover mixtures on marginal lands.

Cereal crops and perennial grasses are among the most important sources for an increased production of biomass. In these crops there is a large potential for increasing the quantity of harvested biomass per unit agricultural land via targeted plant breeding. Increased yield of cereal straw has not hitherto been a goal in plant breeding. On the contrary, the focus has been on developing new dwarf and semi-dwarf genotypes, which in combination with ample nitrogen fertilizer supply and new growth regulators has been able to give a high grain yield. It has, however, been documented that even among commercial wheat genotypes there is a considerable variation in straw yields, which can be increased by 25-35% without compromising grain yields.

The research will focus on ways to increase crop yield and crop quality parameters essential for the biorefining process. Possibilities for improving production of plant biomass by means of improving the crop production systems, the harvest systems as well as the storage systems will be investigated. Both the quantity and quality of the biomass or fractions of the biomass may be improved by modifying the existing systems for production, harvest and storage. A change in crop production may call for changes in the harvest systems and storage systems and, on the other hand, the specific quality requirements for biomass for a given biorefinery system may demand adjusted harvest and storage practices in order to optimize the supply chain.

Major hypotheses to be tested are:

- The composition of biomass may be controlled by management factors such as nutrient supply, harvest time, species and genotype selection

- There are genotypes of arable crop species that are much more efficient in converting solar energy and tolerate abiotic stress, and therefore are capable of delivering higher yields of biomass (incl. crop residues) without competing with the current food production
- Targeted plant breeding and genetic engineering will have a significant impact on biomass for biorefinery purposes
- It is possible to approximately double the biomass yield compared to todays' grain production system, while emissions of e.g. nitrate and greenhouse gases are reduced significantly.
- Green biomass crops can produce similar or higher amounts of protein rich fodder as todays grain and seed based systems, while at the same time delivering resources for materials and energy
- Minerals recirculated from the biorefinery process can stimulate crop yields and sustainability.

4 Value chains

In the first part of the project, it was decided to focus on two selected value chains. A value chain with green biomass in the form of clover and grass which includes cultivation, transportation, storage, and refining of green protein, and a value chain with yellow biomass in the form of straw which also includes cultivation, transportation, storage and refining of high value products. The two value chains are illustrated in the following figures.

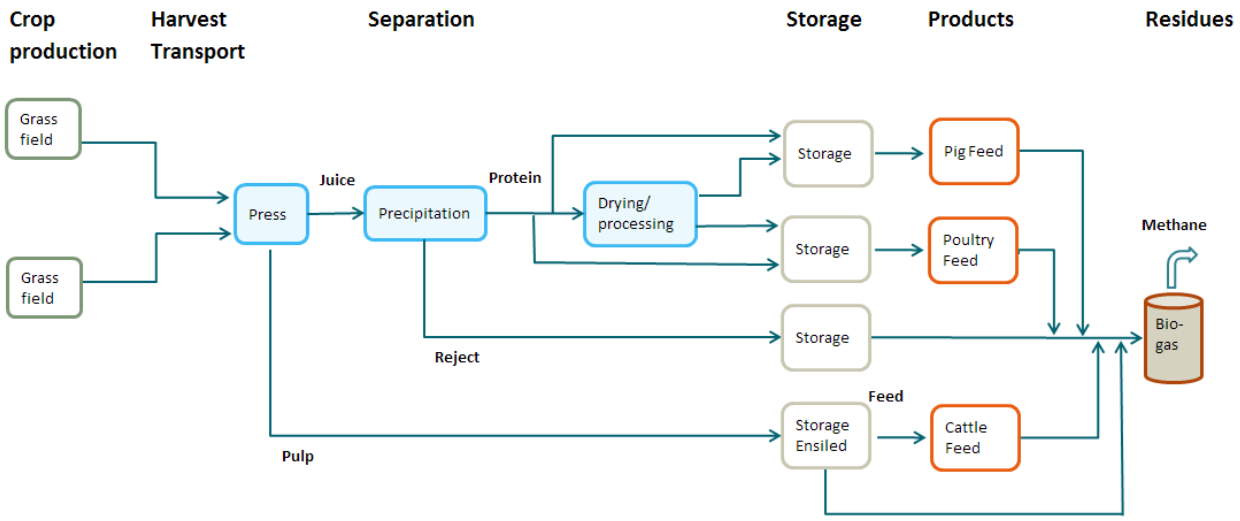

Figure 1 Selected value-chain for green biomass as clover grass

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Figure 2 Selected value-chain for yellow biomass as straw

5 Overall plan for R&I

The experimental work focuses on:

- Composition of agricultural systems and yield optimization
- Characterization and molecular mapping of cereal genotypes
- Physiological and biochemical interactions between nitrogen metabolism and biomass accumulation
- Modelling of the supply chain for biomass for biorefinement

5.1 Composition of agricultural systems and yield optimization

The Innovative agricultural production systems include highly productive perennial grass systems, perennial low-input, high-diversity grasslands, and double crops (e.g. hemp + rape seed and triticale + winter rye). These options will be thoroughly scrutinised to evaluate their productivity and sustainability in terms of carbon sequestration and nutrient emissions. The quality of the harvested biomass will in cooperation with material from other projects be analysed with respect to protein for fodder, convertibility into sugars and possibly other valuable components, as affected by soil and crop type, harvest time etc. A PhD project at AU with special focus on aspects of protein production will be the core activity and be conducted in cooperation with Project 2 (P2).

Cropping systems with different combinations are established at AU-Foulum (loamy sand), AU-Jyndevad (coarse sand) and AU-Flakkebjerg (sandy loam) with four replications in an incomplete block design. In addition to measurements of biomass yield, the crop growth is continuously followed in all crops by remote sensing registration of green leaf area development, which will reveal the efficiency of solar radiation capture. Soil carbon content of all experimental plots is determined before the start of the experiment, and repeated measurements are taken to determine the development over time. Nitrate leaching is measured in all plots and will be used to establish a total N-balance of the different systems.

Biomass samples with a wide variation in quality is analysed for its content of protein in order to describe the variation between cropping systems in quantity, quality and extractability of protein as part of the study. The investigation will be done in cooperation with WP2 and biomass is delivered for further experiments.

Environmental data (nitrate leaching, soil carbon balance, pesticide use) from a range of cropping systems will be delivered for the platform for socioeconomics, sustainability and ethics, as well as data on inputs and outputs from the production.

5.2 Characterization and molecular mapping of cereal genotypes

Straw length, thickness and mechanical strength are controlled by different genes which are involved in the biosynthesis of cell wall components and phytohormones. Some of these genes are known but there is a need for further research in order to elucidate new genes, QTLs and molecular markers in interaction with climatic factors and soil conditions, particularly the timing of nitrogen supply which has a decisive influence of the growth and structure of cereal crops.

Activities include:

- Identification of the genetic variation in straw yield and quality among cereal crops (winter wheat, winter triticale, winter barley and spring barley) including a wide range of varieties and breeding lines grown under field conditions.
- A selection of wheat varieties will be analyzed for SNP markers (9K Chip) to give dense marker coverage throughout wheat genomes.

- Genotype (SNP data) and phenotype data (straw yield and quality) will be combined to provide for the development of DNA markers for biomass traits in wheat, thereby creating the basis for the use of genomic selection in future breeding programs.
- Developed markers will be validated on an independent set of wheat varieties.

5.3 Physiological and biochemical interactions between nitrogen metabolism and biomass accumulation

Nitrogen is the main driver of biomass yield in wheat and better knowledge about timing and level of N supply is essential for development of new nitrogen fertilization strategies which can optimize stem cell wall material for biorefining while at the same time improving nitrogen utilisation efficiency. The focus is on the physiological and biochemical interactions between nitrogen metabolism, biomass accumulation and cell wall properties in wheat straw.

Activities include:

- Field experiments with 10-15 different wheat and triticale genotypes growing of 4-5 levels of N fertilizer application
- Quantification of biomass development, proteins and other nitrogen containing compounds in the straw during critical growth stages of winter wheat and triticale
- Proteomics of cell wall proteins in wheat straw

5.4 Modelling of the supply chain for biomass for biorefinement

Knowledge on how biomass for biorefinement should be collected, handled, transported, and stored in order to continuously supply a biorefinement facility with adequate biomass of high quality is essential for running the facility. A planning tool is under development where different options for collection, handling, transportation, etc. can be selected and the impact on the selections on economy is visualized. The tool will enable the farmer to optimize crop production with focus on delivery for biorefinement.

The current working procedures within harvest, logistics, and storage are described and a number of new technical solutions are included in the calculations of investment and operational costs. The economic impacts on choosing between different operating conditions are described. The activities further include an assessment of loss of biomass during handling and storage.

Crops from field trials (wheat straw and grass) are used as crop models in the project, but other crops will also be modelled (rape straw, beets). For each crop the following parameters will be determined:

- Biomass availability: Suggested time of harvesting, availability period for the crop/biomass, and yield of biomass per hectare.
- Suggested existing harvesting method. Cost incurred by harvesting using suggested and, if applicable, alternative harvesting methods
- Transportation costs incurred by transportation of biomass, e.g. from field to storage facility.
- Biomass storage consequences. Suggested optimal storage method. Storage cost. Expected qualitative and quantitative degradation of biomass as a result of storage method.
- Biomass pre-treatment costs.
- Estimates of total production costs.

- Projected price of biomass paid by the biorefining production facility based on e.g. availability and demand of biomass at the time of sale.

It is essential for the planning tool to be a success that results from the field trials and special requirements of harvest, logistics, pretreatment, and storage of the biomasses for biorefinement are reported to this subproject from other parts of Project 1, so that the requirements can be incorporated in the planning toll allowing the farmers to adjust their production according to the needs.

6 Experimental activities planned for 2016-2017

At Aarhus University, the efforts in research plots at locations in Foulum (JB4) and Flakkebjerg (JB6) are continued. The research activities at Jyndevad (JB1) are closed down by the university and the last samples from the Biovalue experiments here have been taken in spring 2016. The experimental plan and the designated plots are briefly discussed in the action plans. Danish Technological Institute has launched various storage trials with ensiling of e.g. fiber fraction from grass after protein extraction and straw co-ensiled with wet biomasses such as catch crops. Similarly, Sejet and KU designated a number of plots with different genotypes of wheat.

6.1 Experimental plan A- Biomass crops for biorefinery, AU

The project continues a series of plots established at the University of Aarhus both at Foulum and Flakkebjerg research stations representing large differences in soil quality and climate. Harvesting of biomass from the plots for delivery to other projects can be continued.

All samples from 2013 and 2014 have now been analyzed for their protein compartmentation in fractions A, B1, B2, B3, and C according to the Cornell Net Carbohydrate and Protein System (CNCPS). The dry matter samples will during 2016 be scanned for their NIR (and possibly other spectras, e.g. IR) reflection in order to establish a library of specters to predict the protein components in a cheap and fast way.

6.2 Experimental plan B – Composition of agricultural systems, DTI

Planned activities during 2016 and 2017 will have a main focus on storage of biomass and biomass fractions. Experimental activities will include pilot-scale storage trials (silos with a height of 2.7 m^3 silos) with ensiling of the grass fiber fraction after extraction of juice with protein and soluble sugars. This will comprise termination of a trial started in 2015 as well as initiation of a new trial during summer/autumn 2016 to be terminated during summer 2017. Effluent run-off will be measured over time, final mass loss will be measured, and samples will be delivered to AU/KU for quality analyses.

Experimental activities will also include continuation and termination of lab-scale storage trials with co-ensiling of straw and catch crops from two strip harvesting field trials in 2015. Ensiling will be terminated after 0, 2, 4, 6, 8 and 10 months of ensiling, and quality changes as a function of ensiling time will be analyzed in terms of methane potential.

Moreover, a desk-study will be carried out to elucidate the potential of biomass from meadows as a source for protein production. This will include screening of existing knowledge about the magnitude of potential areas in Denmark and the effect of harvest time on potential yield and quality in terms of protein content.

6.3 Experimental plan C - Characterization of cereal genotypes, Sejet/KU

Zoned experiments at Sejet embracing varieties of winter wheat are continued. The aim is to generate knowledge about variation in straw yield and quality in winter wheat. The field experiment is conducted at Sejet and the wheat is grown for a 3 year period. Sejet has a trial harvester with an integrated scale for straw yield measurement, and a cutter mechanism that make sampling of straw possible, such that straw can be analyzed for fibers and other ingredients. The choice of varieties for the breeding program is conducted such that variation in straw yield, straw height and type of straw are represented. The wheat

varieties are genotyped by Trait Genetics (15K chip) which provides the basis for genome-wide association study (GWAS) and allows for development of a marker system for efficient processing of the relevant straw parameters.

A field experiment with winter wheat is conducted by the Department of Plant and Environmental Sciences, University of Copenhagen, at the KU experimental farm Højbakkegård in Taastrup. The field experiment embrace 8 different winter wheat varieties and two Triticale variety which has been selected to represent a diverse spectrum of straw and grain yield, caused both by differences in straw length and culm density (see Table 1). The experimental design is a randomized plot design (plot size 15 m2) with five different nitrogen treatments in three replicates in each of four blocks. The nitrogen treatments are included to study the effects of nitrogen application on straw productivity and composition, and to provide the formulation of nitrogen strategies to ensure high straw quality and productivity. The five nitrogen-regimes were 60, 120, 180, 240, 300 kg mineral N/ha, corresponding to low, optimum and high nitrogen supply.

Plant material is sampled at several occasions during the growing season, the dry matter yield is measured and the material is stored in frozen condition for further analysis of cell wall composition, concentration of other mineral elements, and enzymatic saccharification. At final harvest, all plots are combine harvested and the weight of grain and straw per unit land area carefully recorded. Samples of the mature crop are also taken for further analysis of straw and grain quality parameters.

Table 1. Overview of wheat and Triticale genotypes included in the field experiment in Taastrup.

Variety	Reason for choice	Crop	Breeder	Released	Parents
Ambition	medium long straw, low culm dens.	Winter wheat	Nordic Seed	2005	Ritmo x A 0119.7
Audi	long straw, low culm dens.	Winter wheat	Nordic Seed	2006	Ritmo x A 0119.7
Genius	relatively long strong	Winter wheat	NordSaat	-	
Gedser	short straw	Winter wheat	Nordic Seed	2011	Robigus x (Stakado x Kris)
Hereford	well adapted, medium straw yield	Winter wheat	Sejet	2007	Solist x Deben
Hybery	hybrid wheat with long stiff straw	Winter wheat	Saaten-Union	-	
Evolution	'english type' with low straw yield	Winter wheat	(Sejet)	-	
JB Asano	high straw yield, long straw	Winter wheat	Breun		no information
Jensen	long straw	Winter wheat	Nordic Seed	2009	CM8228 x Robigus
Mariboss	high straw yield, high culm dens.	Winter wheat	Nordic Seed	2008	Hunter x K 6011.05
Nakskov	short straw	Winter wheat	Nordic Seed	2012	Biscay x 1818714
SJ8544003	bushy, grass-like type	Winter wheat	Sejet	-	
SJ070909-38	Triticale with high straw yield	Triticale	Sejet	-	
Pierrot	long straw	Winter wheat	Sejet	2009	(Abunda x Sj 0199) x Beaufort
Tuareg	long straw	Winter wheat	NordSaat	2007	Kris x Dekan

7 Deliverables, activities and milestones 2016-2017 (2018)

KU:

Objective: Exploiding the potential of genotypic differences in wheat varieties. Breeding of new crop genotypes with improved yield and quality of biomass.

Activity: Field experiment with 10 winter wheat and Triticale varieties growing under three different nitrogen supplies at the experimental farm Højbakkegård in Taastrup continued in 2016.

- Deliverable: Results (incl. paper) on the potential for increasing wheat straw yields and straw composition without compromising grain yields (Paper subm. Dec 2016)
- Milestone: Completion of analysis of wheat samples from field experiment 2015
- Milestone: Statistical analysis of data from wheat field experiments 2014 and 2015 completed

Activity: Development of method

- Deliverable: Optimized method incl pre-treatment for high-throughput screening of sugar release after enzymatic saccharification of wheat straw (protocol Sep. 2016; publication Jan 2017)
- Milestone: Core parameters for high-throughput screening of sugar release after enzymatic saccharification of wheat straw identified

Objective: Use targeted plant breeding to increase the quantity of harvested biomass per unit agricultural land of cereal crops and perennial grasses.

Activity: Analysis of biochemical traits (cell wall composition), nitrogen and carbon content in large panel of wheat genotypes

Activity: Genome wide association analysis of wheat traits (collaboration with Sejet)

- Deliverable: Biomarkers for straw productivity and quality in winter wheat (collaboration with Sejet)(New samples harvested Aug. 2016; analyses completed spring 2017)
    - Milestone: First molecular markers for wheat straw yield and composition (in collaboration with Sejet) available

Objective: Achieve basic understanding of the fundamental interactions between genotype, environment and management factors that can be exploited to sustainably intensify the biomass yield per unit land area and to deliver tailored biomass qualities for biorefineries

Activity: Analytical characterization of different nitrogen pools and compounds in wheat straw

- Deliverable: Results on nitrogen pools and compounds in wheat straw as affected by maturation stage and nitrogen application rate – relevant for designing new nitrogen strategies (Paper subm. Oct. 2016)
    - Milestone: First complete nitrogen budget for wheat pools and compounds in wheat straw available

Activity: Determination of mineral composition of green biomass fractions from biorefinement of green biomasses to soluble fraction, green-protein pellet, and fibrous pulp. Collaboration with project 2.

- Deliverable: Mineral composition of green biomasses distributed on extractable soluble fraction, green-protein pellet and fibrous pulp
    - Milestone: First data on mineral composition of different green biomass fractions

Objective: Optimize land management, logistics, biomass harvesting and storage.

Activity: Pilot-scale storage trials with ensiling of grass fiber after extraction of juice with protein and water soluble sugars (refer also to activity for DTI).

- Deliverables: Results for changes in amino acid profile during ensilation of grass samples
    - Milestones: Samples received June 2017 from DTI for further analysis of amino acid profiles

Sejet:

Objective: Exploding the potential of genotypic differences in wheat varieties. Breeding of new crop genotypes with improved yield and quality of biomass.

Activity: Field experiment with high number of winter wheat varieties at location Sejet will continue in 2016. Genotypes from the field experiment will be genotyped using standard wheat gene-chip (TraitGenetics) as well as in house SNP marker analysis.

- Deliverable: Straw samples as well as phenotyping and genotyping data will be delivered to KU for further analysis
- Milestone: Completion of field-testing 2016 and deliver to KU data to follow up on the GWAS statistical analysis as well data for ongoing analyzing of small wheat population
- Milestone: Implementing the first developed DNA-markers for straw yields and quality in own breeding material

AU:

Objective: Increase the quantity and quality of the biomass raw material available for biorefining & Exploiting the potential of genotypic variation

Activity: Analysis of field experiments

- Deliverable: Results from the field experiments from 2013-2015
    - Milestone: Radiation capture and productivity of all crops 2013-2015 registered and used for calculation of RadiationUse Efficience (May 2016)
    - Milestone: Nitrogen input, uptake, and leaching from all crops analysed (Dec 2016)
    - Milestone: Soil analyses taken in all experimental plots for analysis in comparison with "before-trial-plot-samples" in order to analyse for the development in soil organic matter content (N and C) (Feb 2017)

Activity: Publication of results related to the objective

- Deliverable: Paper: Kiril Manevski, Poul E. Lærke, Sanmohan Baby, Xiurong Jiao, Uffe Jørgensen Light interception and biomass productivity of innovative cropping systems for biorefinery at two locations in Denmark. To be submitted for Industrial Crops & Products OR European J. Agronomy (Jul 2016)
- Deliverable: Paper: Manevski, K., Jørgensen, U. & Lærke P.E. Modeling productivity and water balance of innovative cropping systems for biorefinery over three seasons at two locations in Denmark. Invited for Agricultural Systems (Sep 2016)
- Deliverable: Paper: Zeinab Solati, Poul Erik Lærke, Kiril Manevski & Uffe Jørgensen. Protein content and extractability in innovative cropping systems designed for biorefinery separation. To be submitted for Industrial Crops & Products (Oct 2016)
- Deliverable: Paper: Manevski, K., Jørgensen, U. & Lærke P.E. Nitrogen balances of innovative cropping systems for biorefinery over three seasons at two locations in Denmark. To be submitted for Nutrient Cycling (Jan 2017)
- Deliverable: Paper: Manevski, K., Jørgensen, U. & Lærke P.E. Development of soil organic matter content of innovative cropping systems for biorefinery over five years in Denmark. To be submitted for Soil Use and Management (Dec 2017)

Objective: Testing of protein fodder quality and quantity in green crops (extraction of proteins will be carried out in project 2)

Activity: Analysis of field experiments

- Deliverable: Results from the field experiments from 2013-2014
    - Milestone: All Foulum samples harvested in 2013 and 2014 separated in protein fractions by the CNCPS method (Apr 2016)
    - Milestone: All Foulum samples harvested in 2013 and 2014 scanned by NIR (Oct. 2016)

Activity: Publication of results related to the objective

- Deliverable: Paper: Zeinab Solati, Poul Erik Lærke, Kiril Manevski & Uffe Jørgensen. Protein content and extractability in innovative cropping systems designed for biorefinery separation. To be submitted for Industrial Crops & Products (Oct 2016)

In addition,

- Crop growth is continuously followed by remote sensing registration of green leaf area development.
- Nitrate leaching is continuously measured in all plots.
- Harvest and yield calculations for all plots: May-December 2016
- Biomass samples for other project partners on request.

SEGES:

Objective: Optimize land management, logistics, biomass harvesting and storage.

Sub-objective: To describe transport options for liquids, and wet and dry biomasses leaving the biorefinery.

Activity: The end products from the biorefinement process will be transported from the biorefinement facility to other facilities or returned to the farmer. The different end products are not yet known, but the excel model should be able to handle the transport as soon as end location and product type is known.

- Deliverables: An add-on to the model that can calculate transportation costs of end products from the biorefinement process.
    - Milestones: A model handling transport from the facility. Oct. 2016

Sub-objective: To optimize storage and estimation of available wet biomass in store

Activity: Wet biomasses need proper storage to maintain carbohydrates and protein. Depending on biomass type (grass, maize, beets) different storage options are possible. Best practice will be described.

- Deliverables: A review on different storage option for each of the 3 biomasses including a comparison of cost for the different options.
- Milestones: A review report on storage options for wet biomasses. May 2016

Activity: The exact degree of degradation of wet biomass is difficult to foresee and cannot be directly modelled. However on basis of expected degradation under optimal conditions supplemented with monthly inspections it will be possible to foresee the amount of biomass in store and the needed storage capacity.

- Deliverables: An add-on to the model where expected degradation can be inserted. Calculation of remaining biomass. A note on how storage loss can be diminished. A simple model of expected stock
- Milestones: Improved model including expected stock on a monthly basis. July 2016

Sub-objective: To ensure that cost in the model remains updated and that new information on storage options, pretreatment, handling, and transport is included in the model.

Activity: The model will be continuously updated and improved

- Deliverables: An updated model
- Milestones: Ongoing

DTI:

Objective: Optimize land management, logistics, biomass harvesting and storage.

Activity: Pilot-scale storage trials with ensiling of grass fiber after extraction of juice with protein and water soluble sugars. Measurement of effluent run-off and mass loss. Initiated 2015/2016, terminated summer 2017. Collaboration with project 2.

- Deliverables: Delivery of samples to AU/KU. Contribution to reporting of results.
- Milestones: Samples delivered June 2017

Activity: Continuation/termination of lab-scale storage trials with co-ensiling of straw and catch crops from strip harvesting field trials in 2015. Analysis of quality change over ensiling time. Initiated October 2015, terminated February 2017.

- Deliverables: Popular article with main results. Delivery of input to logistic modelling by SEGES.
- Milestones: Popular article published April 2017

Activity: Elaboration of scientific paper on co-ensiling of straw and sugar beet top, based on storage trial from November 2013 to August 2014. Collaboration with University of Southern Denmark.

- Deliverables: Scientific paper.
- Milestones: Scientific paper published June 2017.

Objective: Develop cost-effective management practices for marginal lands to harvest their biomass potential.

Activity: Desk study on potential protein production based on grass from meadows. Potential areas, effect of harvest time, potential yield and quality (protein content). Initiated December 2015, finalized autumn 2016.

- Deliverables: Short report in English.
    - Milestones: Report published December 2016.

8 Plan for interactions with other projects

The activities in this project are closely coordinated with the activities in P2. Biomasses from the trials in P1 is used for the trials in the other projects, especially in the P2, where there will be an intense collaboration in reaching the common aim of finding ways of producing new quality proteins from green biomass.

The coordination of activities with the SME Innovation Platform will be intense. Ideas for the involvement of SME's will come from both the projects and from the Innovation Platform. It is planned to hold regular meetings with the Innovation Platform at Danish Technological Institute and the innovation network Inbiom at Agro Business Park.

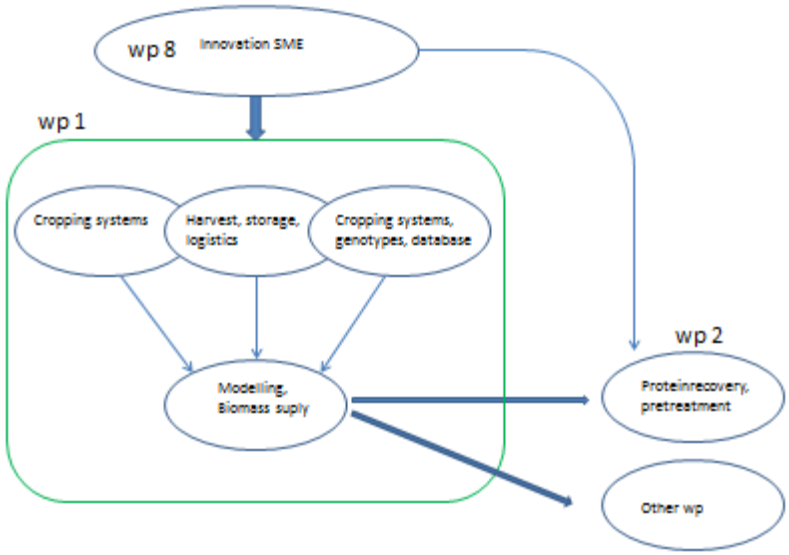

Figure 8-1 Organizing of activities in project 1. Sketch of the organizing of activities in project 1 and the link to other projects

Data on nitrate leaching, input/output and soil carbon from different cropping systems will be delivered for the platform for socioeconomics, sustainability and ethics.

The activities are expected to cause a positive interaction with other R&D activities of Danish Technological Institute within the areas production, quality and utilization of biomass for various purposes. Activities may, for instance, benefit from field trial work carried out in relation to other projects.

9 Link to other projects

The effort in the project is focused in two value chains for green and yellow biomass.

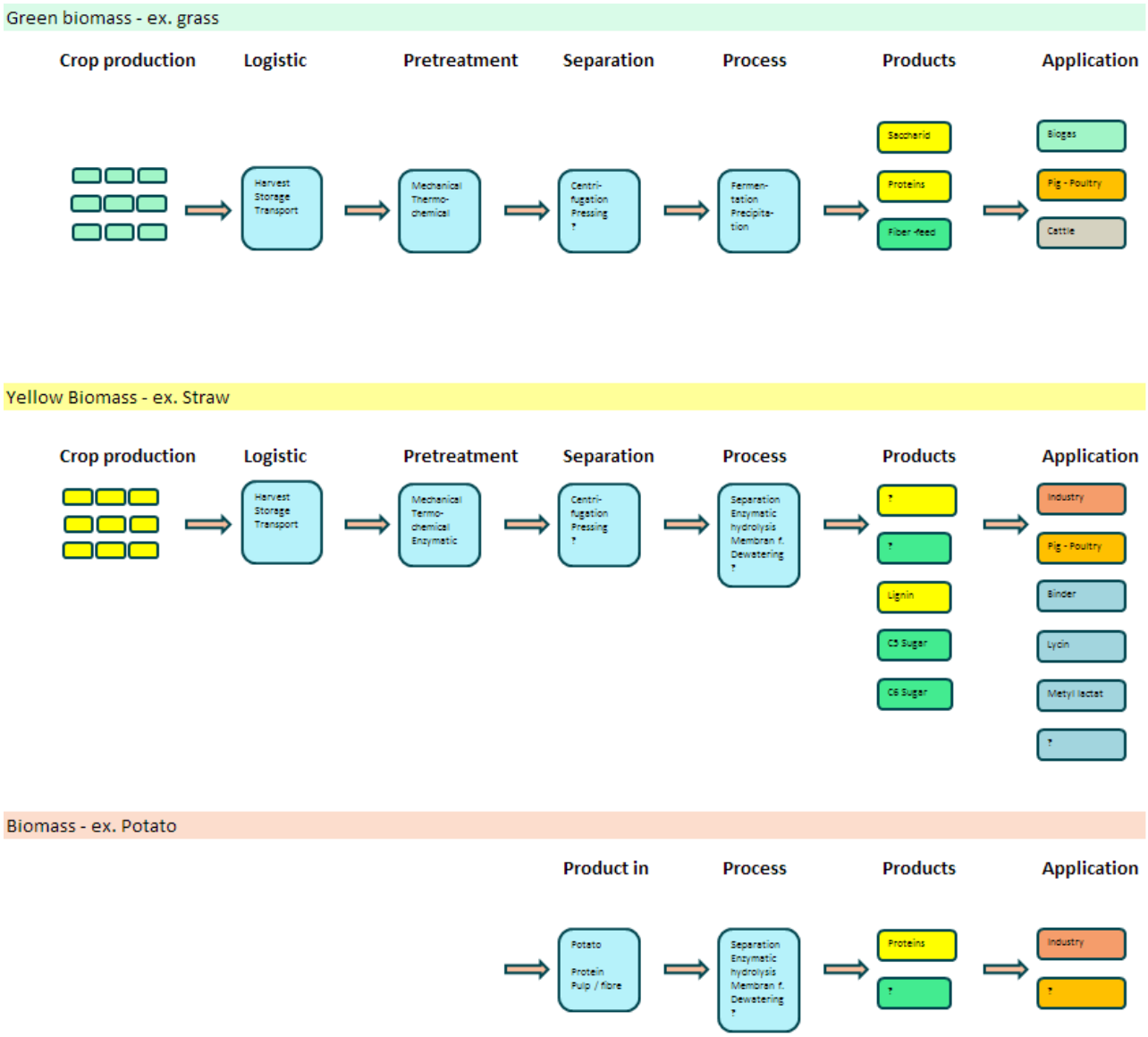

Figure 2 Simplification of the selected value chains for green and yellow biomass

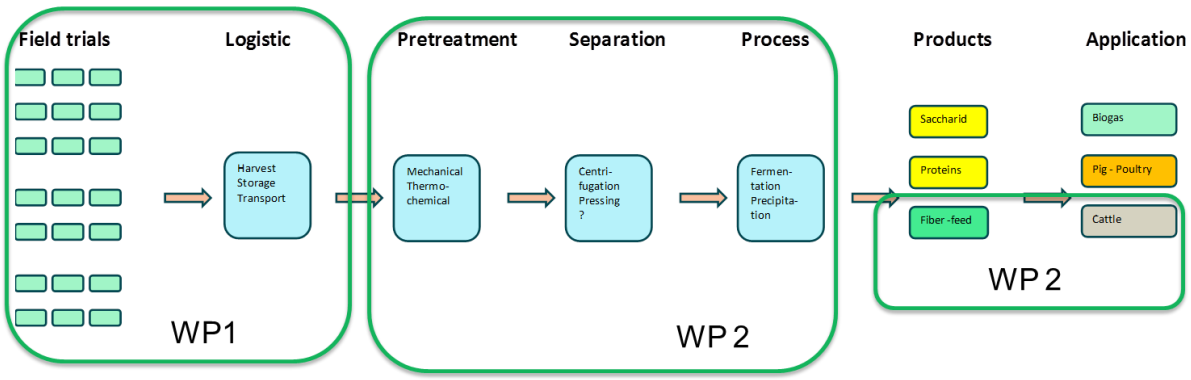

Figure 3 P1 and P2 participation in the green value chain

Project 1 (P1) is focused on the first part of the green value chain and collaborate closely with P2 with the separation of green proteins for feed.

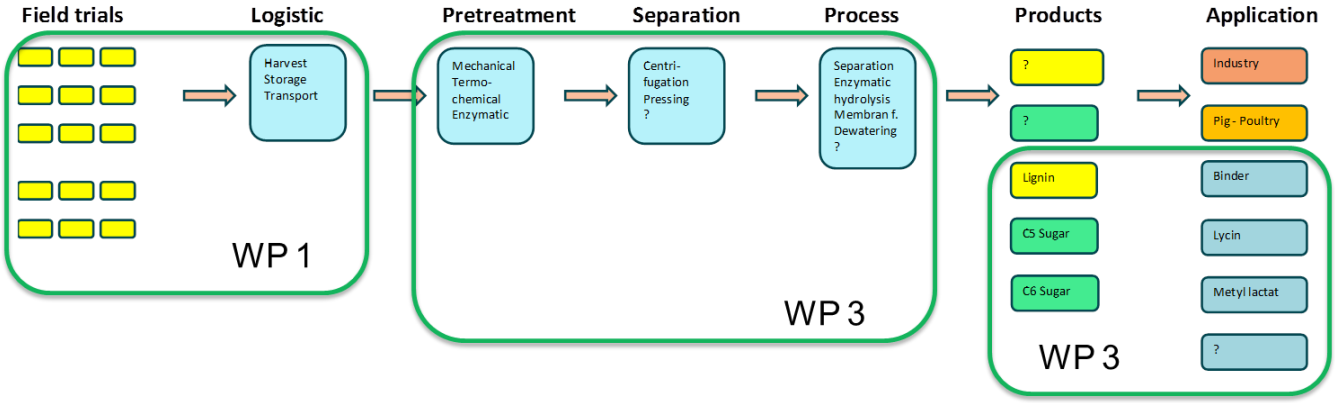

Figure 4 P1 and P3 participation in the yellow value chain

Likewise the project 1 is focused on the first part of the value chain for yellow biomass.

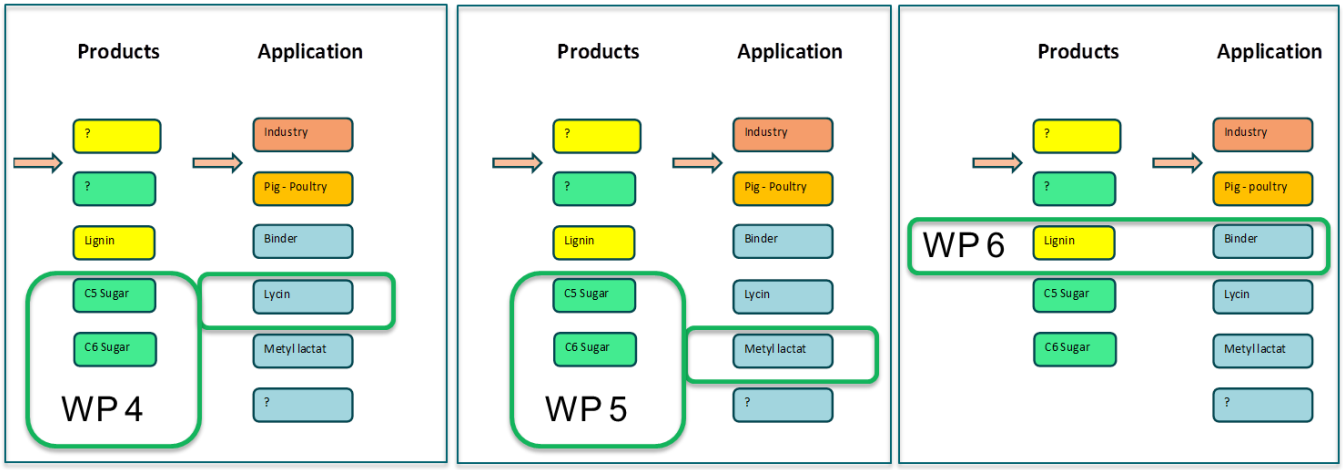

Figure 5 P4, P5 and P6 focusing mainly on the products and applications in the yellow value chain

10 Personnel recruitment plan

No planned recruitments for 2016

Michael Støckler has left SEGES and the project ultimo April 2016. His duties in project 1 have been transferred to Lone Abildgaard (SEGES).

11 Partners contact information

Partner	Contact	Mail	Phone	Mobile
KU	Jane Lindedam	lindedam@plen.ku.dk	3532 0550	2328 6740
SEGES	Lone Abildgaard	loa@seges.dk		3051 6673
Danish Technological Institute	Søren Ugilt Larsen	slar@teknologisk.dk		7220 3317
AU	Uffe Jørgensen	Uffe.jorgensen@agro.au.dk	8715 7729	2133 7831
KU	Jan K. Schjørring	jks@life.ku.dk	3533 3495	2371 0002
DLG, Sejet	Birger Eriksen	bee@sejet.dk	7627 5204	4018 6555
Arla	Kjell Lunden Pettersson	kjell.lunden-pettersson@arlafoods.com		

12 Budget

Overall budget for project 1

Partner	Total	DSF-grant	Self-financing	Cash-flow
Arla	3.400.000			3.400.000
DLG	2.700.000		1.700.000	1.000.000
SEGES	4.500.000	2.000.000	2.500.000	
Danish Technological Institute	3.200.000	3.200.000		
KU	3.905.200	2.200.000	1.705.200	
AU	2.977.600	2.200.000	777.600	
Total	**20.682.800**	**9.600.000**	**6.682.800**	**4.400.000**

Employee	Institution	DSF-grant	Self-financing	Cash-flow
PhD 1.1	KU	260.000	540.000	1.060.000
PhD 1.2	KU	780.000	540.000	540.000
PhD 1.3	AU	780.000	540.000	540.000
Postdoc	KU			500.000
Postdoc	AU			1.700.000
Postdoc	AU	40.000		60.000
PD drift	KU	66.667		
PD drift	AU	240.000		
Total		**2.166.667**	**1.620.000**	**4.400.000**