COMBINE

COMBINE AND THE PROGRASS® - IDEA

The EU-project COMBINE focuses on abandoned urban, natural and agricultural areas of Northwest Europe. By the innovative PROGRASS® approach previously waste biomass will be utilised for energy production. A large variety of grassland sites are suitable for this approach: semi-natural grasslands, set-aside meadows, road- and railroad-side grass verges, but also other types of green cut can be processed.

For the protection of wildlife, the ecologically most valuable, semi-natural areas can be mowed only late in the year. Due to the late mowing, the green cut is less suitable for animal feeding or for use in biogas plants. However, a further decrease of agricultural activities could threaten the open character of many European grasslands and would favour a conversion to scrub-lands. COMBINE helps to conserve the semi-natural character of the these grasslands by converting the green cut into a profitable energy resource which will stimulate further extensive cultivation of the areas by local farmers. Usually the biomass obtained by harvesting extensively used grasslands late in the year contains a large fraction of fibrous and ligneous materials. Such kind of biomass is less suitable for animal feeding. Utilization in biogas plants is inefficient since the material is only poorly digestible and the gas yield would be low. It is also less suited for combustion due to the high ash and nitrogen contents.

These problems can be solved by the innovative IFBB technology (integrated generation of solid fuel and biogas from biomass) which is the heart of the PROGRASS® approach to utilize biomass from grasslands for distributed energy production. During the COMBINE project, the processing of roadside green-cut will be analysed to ensure the absence of contamination by hydrocarbons and heavy metals. In addition, the project provides efficient and standardised methods for harvesting roadside verges and for separating sand from the green cut.

Basic prerequisites for the distributed production of bio-energy by the PROGRASS® approach are:

- Availability, harvest yields of semi-natural and other grassland sites
- Harvesting feasibility of grassland sites (technical and meteorological requirements, accessibility of sites)
- Site location in relation to the bio-energy plant, affecting transportation costs
- Involvement of stakeholders (farmers, local administration, etc.) in the implementation process
- Innovative capacity of the local agricultural community
- Limited market for mature grass as animal feed (large amounts of fibrous contents, low degree of local cattle farming)
- Availability of nearby pellet burning furnaces, demand for grass pellets as solid fuel
- Subsidies for grassland management and production of bio-energy
- Willingness of farmers, energy suppliers and landscape management authorities to carry risks and to invest

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B
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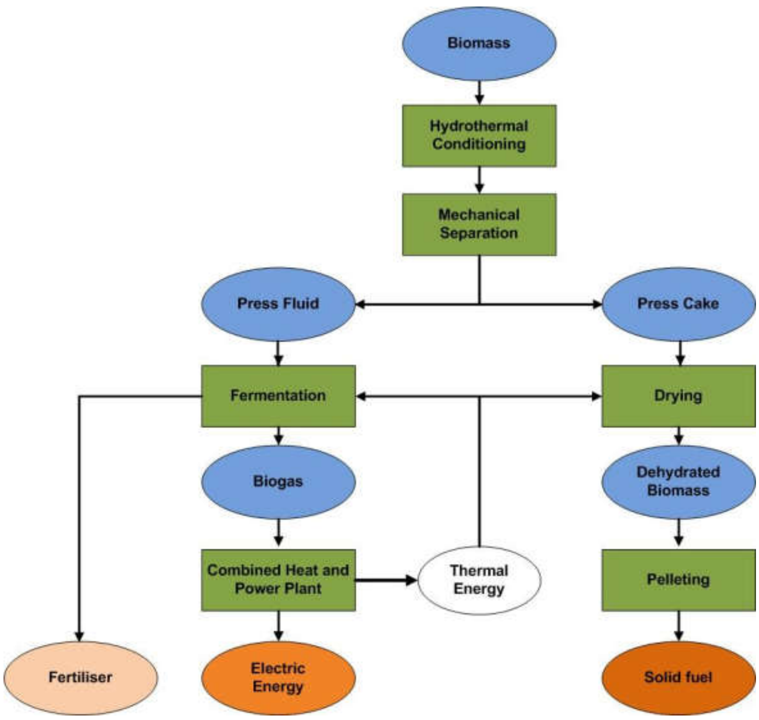
TECHNICAL APPROACH

Integrated Generation of Solid Fuel and Biogas from Biomass

The PROGRASS® technique aims at dividing the grassland silage into a solid part for combustion and a liquid fraction for biogas production. The extraction of minerals and easily digestible compounds into the liquid significantly improves the combustion performance of the solid fraction (press cake) which is converted in a storable biofuel. In addition, the press fluid is a suitable substrate for biogas production.

Procedural Design:

- Silage is first mashed with 40°C warm water.
- Separation of mashed biomass into a solid, fibrous fraction (press cake) to be used as a solid fuel, and a liquid, biologically convertible fraction (press fluid) for the production of biogas and electricity.
- Biogas production from the press fluid and its use in a combined heat and power plant (CHP) to produce electricity and heat.
- Drying of the press cake by the waste heat of the CHP and supply of a fuel with improved combustion characteristics compared to the untreated biomass.
- Prevention of unused waste heat from CHP through year-round drying of the press cake.
- Digestates can be used as valuable fertiliser containing a lot of mineral nutrients.



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PROTOTYPE AND PROCESS STEPS

The University of Kassel has designed an IFBB demonstration plant. It fits into two standard containers in order to facilitate European wide transportation. This prototype includes all of the core elements of the IFBB process.

The pre-treatment of the silage is conducted by a mash water percolation system at a temperature of 40 °C.

Mechanical de-watering of the mashed silage is carried out by a screw press. The resulting press fluid can be converted to biogas by anaerobic digestion in any biogas plant.

Briquetting is done with a hydraulic briquette press with a throughput of 40-110 kg /h. Production of pellets would also be possible.

Feeding of the silage

Hydro-thermal conditioning

Mechanical separation

Fixed bed digesters (press fluid)

Biogas burner and fixed control

Hydraulic briquette press

Process Steps

- Feeding the plant with a band conveyor
- Hydrothermal conditioning (mashing)
- Mechanical separation by a screw press (press liquid – press cake)
- Drying the press cake
- Compression into briquette by a hydraulic press

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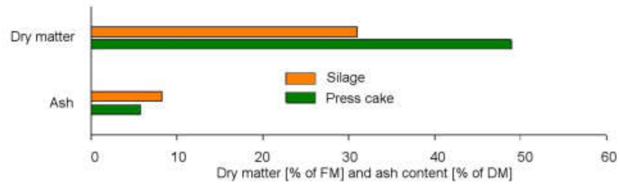
FUEL AND COMBUSTION CHARACTERISTICS

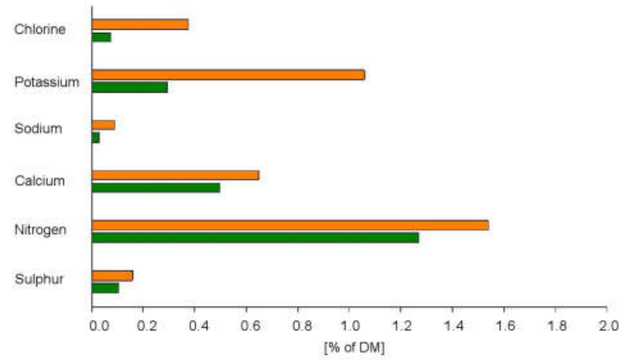
Fuel properties

The separation of the biomass (silage) into a liquid (press fluid) and a solid part (press cake) considerably improves the fuel properties of the latter. This could be verified for the conditions of different European regions and their respective grassland types.

The content of detrimental minerals like sulphur, chlorine, potassium and magnesium is considerably reduced. The nitrogen content is slightly reduced as well. The reduced fraction of sulphur and potassium lowers the corrosion risk.

The mineral content of the fuel is lowest if the primary biomass is grass rich and harvested late in the year.

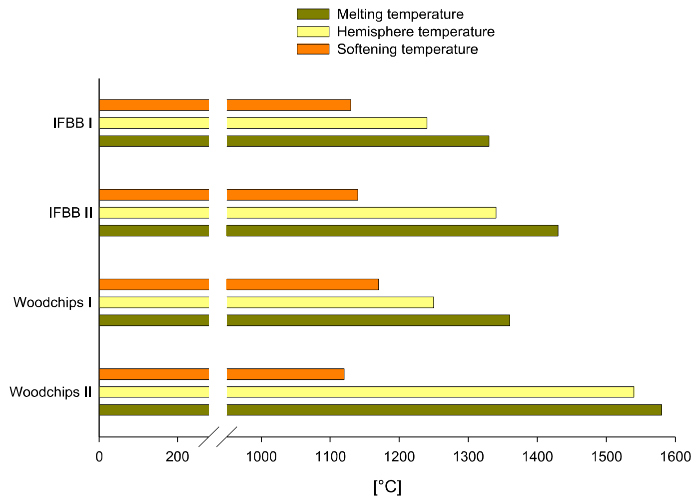




Combustion technique

The elution of potassium from the feedstock is especially important, as this leads to a significant upgrading of the fuel in terms of the ash softening behaviour. The softening temperature of the dehydrated grassland fuel is up to 1100 °C and is therefore within the range of typical wood fuels. An ash softening temperature of this magnitude is essential in order to facilitate the low-maintenance and failure-free operation of biomass boilers.

Whereas mashing and mechanical separation of the grassland biomass (IFBB technique) reduces the content of detrimental minerals to the level of firewood, the still high ratio of nitrogen requires an adjusted combustion process. However, with the use of staged combustion burners the emission of nitrogen oxides is low and the limits of the relevant anti-pollution regulations can be observed.



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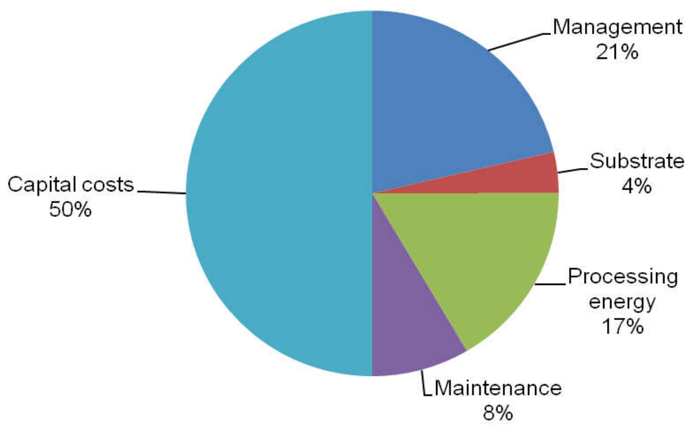
ECONOMIC VIABILITY

Investment calculations have shown that in suitable regional conditions the PROGRASS® concept permits a profitable utilisation of a wide variety of grassland sites. The economic profits of the approach is decisively influenced by the following factors:

- Pellet / briquette price
- Location close to a biogas plant generating low-cost waste heat
- Close distances between plant and grassland sites
- Geographic proximity to an existing biomass pellet or briquette production facility (pellet blending) or to a biomass furnace (eg heating plant)
- Increase of prices of solid fuels
- Investment costs
- Labour costs
- Maintenance and repair
- Costs of processing energy
- Costs and composition of grassland substrates
- Grassland harvest yields
- Transport costs
- Public funding and subsidies (EU area payments, environmental measures applying to agriculture)
- Amount and interests for external capital

Shares of costs of a basic IFBB plant model



Considering characteristic regional conditions, calculations of land use options and plant investment show that the approach can represent a valuable economic alternative. In addition, it contributes to preserving regional economic structures and to protecting semi-natural grassland habitats. Furthermore, the combination of the IFBB-procedure with a biogas plant (IFBB Add-on) leads to an improved economic efficiency by numerous synergy effects.

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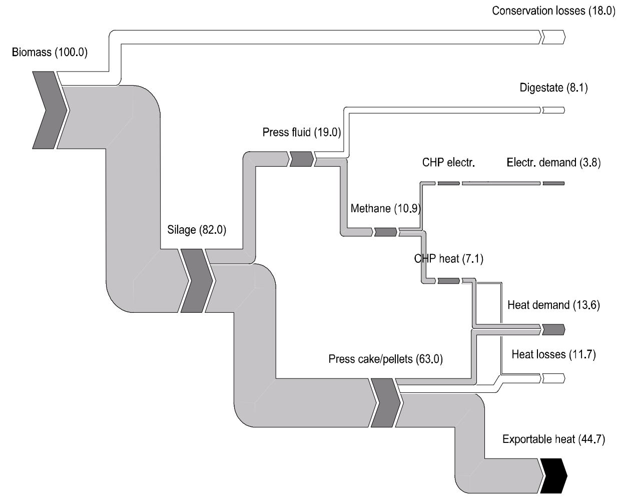
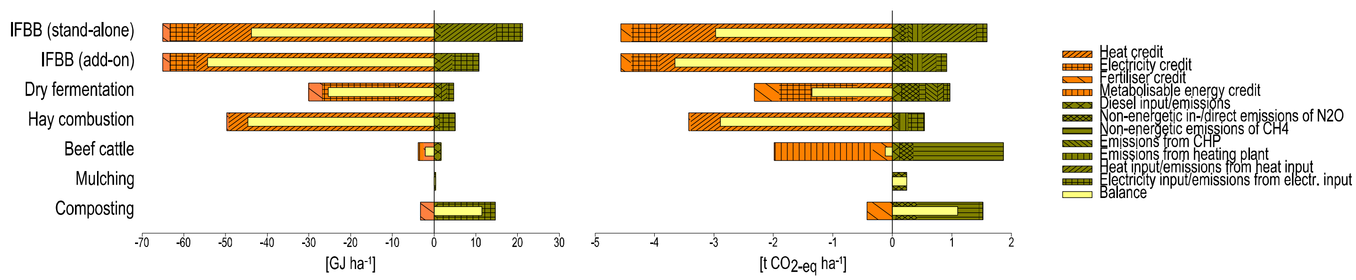
ENERGY AND GREENHOUSE GAS BALANCE

With the PROGRASS® approach previously unused grassland biomass is converted to energy by the IFBB technique. As sketched in the adjacent figure, about 45% of the energy stored in the biomass are transformed into exportable heat. If the IFBB plant is constructed as an add-on to an existing biogas plant, the waste heat of the biogas plant can be utilized for drying the press cake. This enhances the energy efficiency to about 53%. The biogas gain by fermentation of the press fluid meets the additional electricity demand of the IFBB technology .

Even, if the fuel consumption for transport and mowing is included, the energy balance remains positive.



The lower figure displays an analysis of the energy and greenhouse gas balances that are attained by different IFBB related systems. It demonstrates that the highest potential savings of fossil fuel and greenhouse gas emissions are obtained in an integrated system where the IFBB-technique is combined with a biogas plant (IFBB-add-on). An independent IFBB-plant (IFBB stand-alone) and hay combustion exhibit similar energy and greenhouse gas balances, but not as favourable as an IFFB-add-on. The exclusive biogas recovery by dry fermentation offers the lowest saving potentials because of the minor digestibility of the lignin-rich green-cut.



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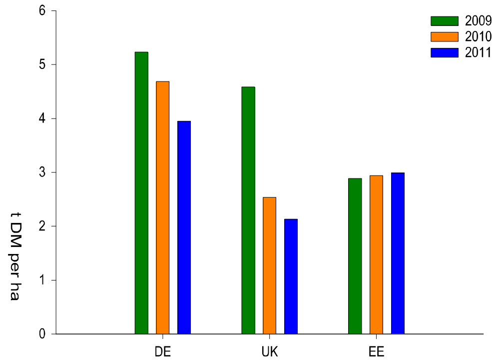
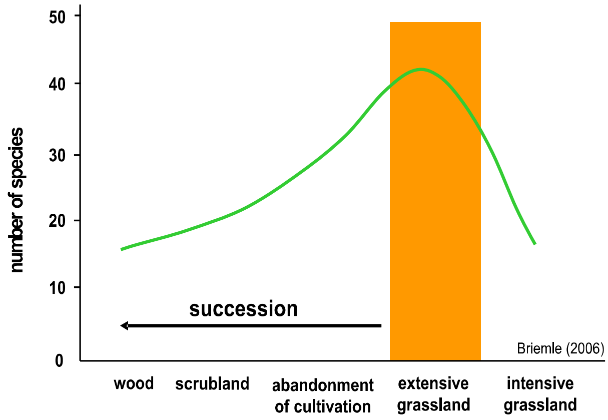
PRODUCTIVITY AND BIODIVERSITY

The adjacent figure displays the results of productivity tests on extensively used (unfertilised) grassland sites within the PROGRASS project.



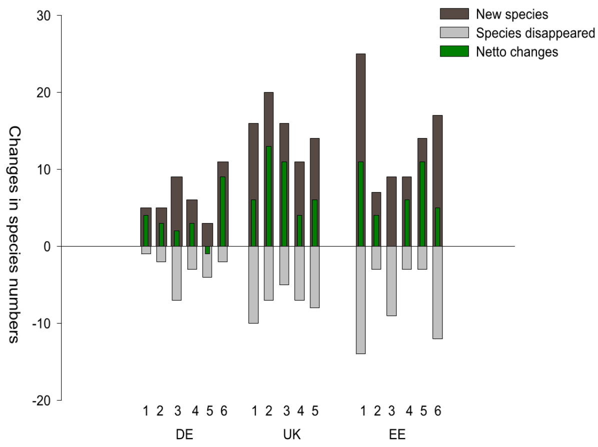
- With extensive mowing the annual grassland yields (t DryMatter /ha) decreased slightly on the German sites and noticeably on the Welsh sites within the 3-years experiment.
- In contrast, on other sites (Estonia) the yields were stable on a low level.

The second figure displays the interrelation between rural land use and biodiversity.



- An intensive grassland use with frequent mowing and manuring reduces the number of species drastically.
- Similarly the richness of species is slowly reduced by a more extensive land use accompanied by a successive transformation to scrublands and woods.

The lower figure shows the changes in the number of species observed during a three years long field experiment in Germany (DE), United Kingdom (UK) and Estonia (EE) on six different sites.



- The strongest gains are observed on the comparably species-poor Welsh sites.
- The species-rich sites in Germany and Estonia could maintain their biodiversity and realise new species too.
- Endangered species of the red list and particular rare species like early purple orchid and globeflower could be conserved.

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STEPS TOWARDS REALISATION

From the beginning the COMBINE approach considers the interests and the needs of all regional stakeholders (farmers, regional administrations, investors, non-governmental organisations, local public, etc). A comprehensive concept of information, training, counselling, and planning choices accompanies and supports the implementation of the PROGRASS technology in new, regional projects. This concept offers face-to-face seminars, printed and web-based information, guided visits to the mobile prototype or to the new full-scale plant in Baden-Baden, and further moderated development workshops.

Steps	Level
Basic knowledge about the PROGRASS® Idea (seminar + visit of an existing plant + individual counselling)	**Level 1:** Basic information for regional stakeholders and potential investors
Additional web-based information (access to the PROGRASS®-Hub) **Basic check of regional potentials** (analysis of the economic feasibility in the region carried out with the PROGRASS® simulation programme) **Decision-finding** (regional workshop to decide for an in-depth feasibility study and investment planning)	**Level 2:** Regional decision-finding
Project development, Investment planning and Acquisition of subsidies/funding (Development workshops)	**Level 3:** Acquisition of capital, simulation and follow-up projects

The basic information phase (Level1) familiarises all interested parties of the region with the prospects offered by COMBINE. Level 2 provides additional in-depth information, a first check of the economic viability for the region in question and further decision-making support. Optionally, external expertise can be ordered for a detailed feasibility study.

In Level 3 regional or transnational workshops provide the opportunity for interested potential partners to transfer the COMBINE concept to their own region, to plan investments , and to get assist in acquiring equity capital and/or additional public funding.

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