SUSTAINABLE FARMING AND NEW PERSPECTIVES FOR THE FARMER AS ENERGY-MANAGER FOR POWER-SUPPLY FROM BIOGAS-REACTOR COUPLED WITH CHP

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A b s t r a c t. The paper shows how plant with biogas reactor can be a part of sustainability issues in agribusiness. Based on the case study from Germany it clarifies the main suppositions, benefits and outcomes for the farmer and producer.

INTRODUCTION

With the recognition of the temporal limitations of fossil fuels (carbon approx. 200 years; oil approx. 50 years; natural gas used approx. 60 years) a process of conscious dealing with energy has started in the 1970, away from the waste and to the sustainable management and use of renewable energy sources [de.wikipedia.org/wiki/nachhaltigkeit].

The umbrella term for all this gentle resources efforts in all areas of human activity, the cultural, social, economic and environmental activities, is sustainability. *Sustainability is the capacity to endure through renewal, maintenance, and sustenance, or nourishment, in contrast to durability, the capacity to endure through unchanging resistance to change. For humans in social systems or ecosystems, sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship the responsible management of resource use* [en.wikipedia.org/wiki/sustainability].

The term "sustainable" in the sense of "state of global equilibrium" arises in 1972 for the first time in the report „The limits to growth" to the "Club of Rome" in a prominent place [Grober 2002]. According to Meadows [1972]: *We are searching for a model output that represents a world system that is: 1. sustainable without sudden and uncontrollable collapse.* The international debate on sustainable development was influenced then in 1983, and in this year established "World Commission on environment and development" of the United Nations. They should develop long-term perspectives for an environmentally friendly development policy.

In the 1987 created final document of "Our common future", known as the Brundtland – Commission report (Gro Harlem Brundtland was Chairman of the Commission) the concept of sustainable development has been defined as follows: *To make sustainable development means that the current generation meets their needs without compromising* *the ability of future generation, to satisfy their own needs* (Episode “the global challenge”, Chapter 3 of “Sustainable Development”, article 27). And Jared Diamond [2005], author of the book “Collapse: How Societies Choose to Fail or Succeed” describes on the basis of examples how destructive the non-sustainable treatment of the environment affects a society.

In Germany “The board of inquiry” defined the concept of sustainability as follows: *The concept of sustainability describes the use of a renewable system in such a way that this system in its essential characteristics remains intact and can regenerate his stock in a natural way* [Deutscher Bundestag 2002].

A SUSTAINABLE SYSTEM IN SENSE OF PERMACULTURE

To live a life that meets the above requirements for sustainability can be done in multiple ways and forms, from controlling living conditions (e.g. ecovillages, eco-municipalities and sustainable cities) to reappraising work practices (e.g. using permaculture see later), green building, sustainable agriculture) or developing and using new technologies that reduce the consumption of resources such as renewable technologies.

To be described later, is especially the production of renewable energy with renewable raw materials (e.g. corn) and By-products of agriculture (e.g. manure, liquid manure) as a new branch in agribusiness chain (Fig. 1.), designed in the sense of permaculture (permanent agriculture) as a self-maintained agricultural system, as first described by the Australians

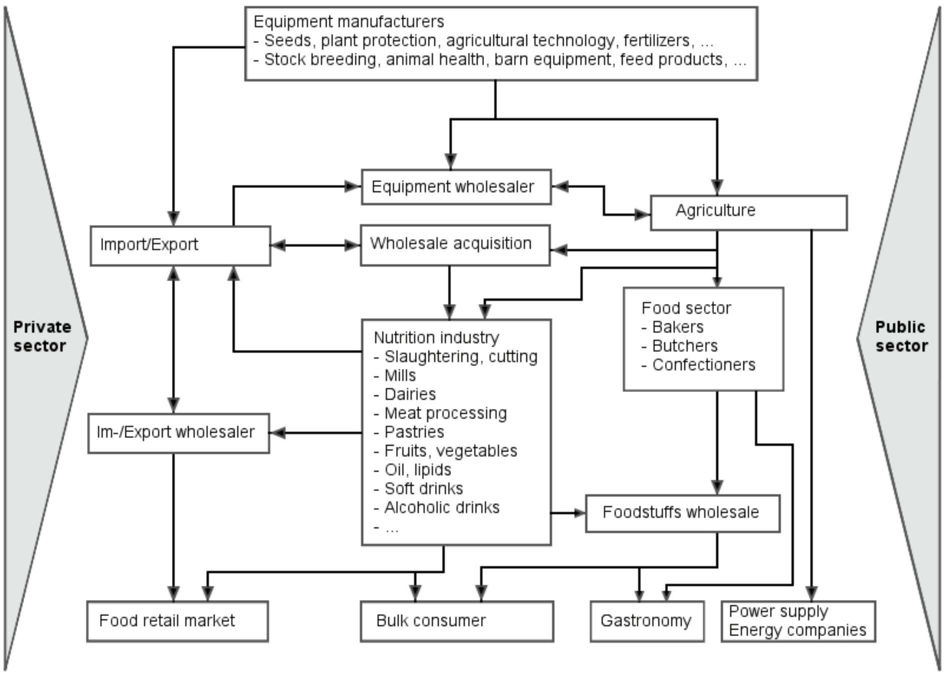

Figure 1. Agribusiness Chain with included energy production
Source: [Strecker 1996].

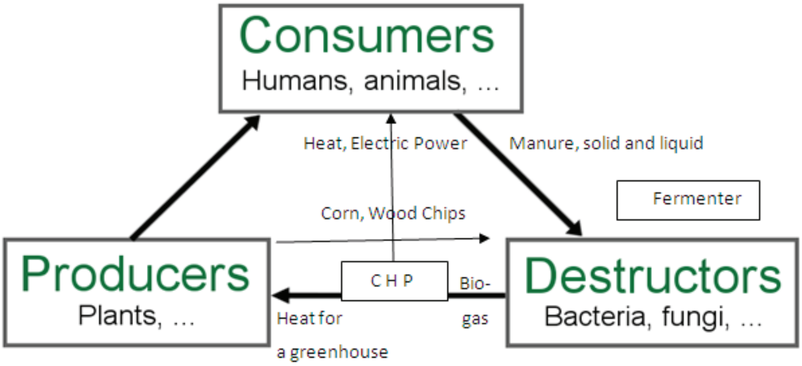

Figure 2. Cycle of raw – materials
Source: [de.wikipedia.org/wiki/Bild:Stoffkreislauf.jpg].

Bill Mollison and David Holmgren during the 1970`s as: *A philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than premature and thoughtless labor; and of looking at plants and animals in all their functions, rather than treating any area as a single project system* [*Healthy Environments and You* 2011]. As it applies with the design principles of Mollison [1978]:

- energy recycling (reusing energy and materials within the system),
- natural resources (using the natural resources of a system),
- and the advanced of Holmgren [2002]: "Use and value renewable resources" (Cautious but productive use of renewable resources as solar, wind, water, biomass. At the same time reduced input of non-renewable resources…). The cycle of raw-materials is shown in figure 2.

THE SYSTEM OF AGRIBUSINESS IN GERMANY

The system of agribusiness in Germany consists of more than 500.000 companies with over 3 millions of employees (this are 9% of all employees in Germany), the total turnover is about 330 billions Euro, this is 13% of the GDP in Germany (2006) [de.wikipedia.org/wiki/Agribusiness]. Table 1. shows the distribution of employees in the different branches of agribusiness in Germany.

As described above the agribusiness sector currently contributes a significant amount to the economy in Germany. However, our agricultural sector as a result of high industrialization with appropriate land use and thus accompanying reduction of agricultural production units is increasingly less competitive. This in particular in the context of increasing globalization and the relocation of the production of agricultural products in area countries (France) or emerging countries (Slovakia, Ukraine) with a low density of industry. So it is for the farmer to find new sales branches.

Table 1. Distribution of Employees in the Area of Agribusiness in Germany

Area	Section of area	No. of employees approx.
Agriculture	Agricultural machinery industry	26 000
	Agricultural machinery trade	45 000
	Plant breeding	10 000
	Animal breeding (animal genetics)	8 000
	Feed	15 000
	Agricultural consulting	15 000
	State agricultural administration	15 000
	Fertilizers, pesticides, animal health	No data
Wholesale trade (purchase business)	Wholesale of agricultural raw materials	52 000
Agriculture	Agriculture, horticulture, viticulture, livestock...	560 000
Manufacturing industries	Food industry	520 000
	Food craft	480 000
Food trade	Food retail	670 000
	Food wholesale	220 000
Bulk Consumers	Foodservice catering	710 000
	Canteens and catering	95 000

Source: [de.wikipedia.org/wiki/Agribusiness].

NEW PERSPECTIVES FOR THE FARMER IN SUSTAINABLE AGRICULTURE

Below some facts which show the environmental benefits of such a system of food production and downstream power generation from biomass:

- regenerative source of energy (renewable, locally available raw materials) as well as saving fossil fuels,
- use previously unused plants and parts of plants (catch, plant remains); CO_2 – emission is almost neutral,
- saving of artificial fertilizers using agronomic fermentation rest. Better plant availability of nutrients. Improved fertilizer quality of the fermentation rest, compared to liquid manure,
- biogas can be used for the production of electricity, heat and as purified methane as fuel for converted vehicles,
- contrary to other renewable energies such as wind and sun, biogas is a weather-independent, storable energy source,
- purified biogas can fed as bio-methane in the gas network and used as a gas substitute,
- increase in value creation/income alternative for the agricultural area.

RESEARCH RESULTS: THE NEW BRANCH OF ENERGY-MANAGEMENT IN AGRIBUSINESS – A CASE STUDY APPROACH

The development of this new branch of agribusiness is to be described below on the example of the development in Germany. A farm with grain production, especially corn and wheat, animal husbandry (cattle, pigs) and a biogas-plant is shown in figure 3.

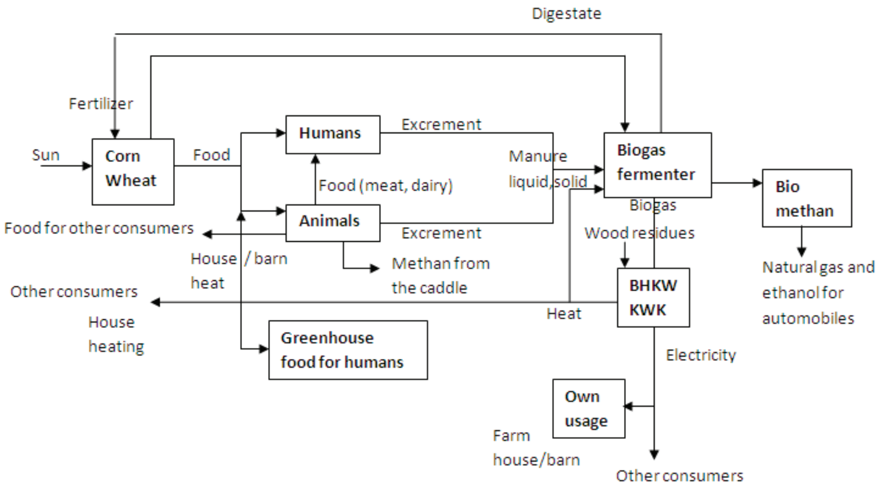

Figure 3. Permaculture Design of a Farm with Grain Production, Animal Husbandry and Energy – Production
Source: own study.

POWER-HEAT-COUPLING WITH BIOGAS

Biogas whose main components methane (CH_4) (share around 60%) and carbone dioxide (CO_2) (share around 40%), is formed during the decomposition of organic matter by special methane bacteria. As feedstock for the production of biogas all materials which can be fermented, such as manure, organic waste, but also renewable raw materials, such as cereals, corn, sunflowers etc. The fermentation process takes place in a biogas-reactor (fermenter) in the exclusion of air and with heat supply (anaerobic digestion). The temperatures must be at least in the range between 30° and 37°C (mesophilic mode). For faster dwell times , as well as in terms of sanitation , the thermophilic operation with temperatures above 50°C is also an option. To avoid high heat losses is the bioreactor insulated. The fermenter volume par example for the plant of one farm is in the size of about 200 m³. The energy content of biogas produced per year for such a plant is approximately 330 MWh. After leaving the biogas reactor, the gas is washed (sulphur extracted) and storaged in a gas storage. From there the downstream power plant (CHP) is supplied with gas, which produces at the same time power and heat. This is part of the governmental plan of decentralized, combined power and heat supply. A part of the generated heat (approx. 20-40%) must be attributed to the heating of the reactor and the pretreatment of food additives in the process. The remaining available heat can be used for the heating of the farm buildings (house, stable, and greenhouse) or the drying of cereals or for operation par example of aquacultures. The remaining rest of heat can be fed into a local heating network. Especially economical efficient and energy – efficient the plant works, if the excess heat can be used all year round or sold. The process electricity requirement for the operation of pumps and a stirrer in the fermenter is in the range of 5-10% of the produced electricity. The remaining electric energy can be used on the farm or fed also into the regional electric network. The digestate from biogas plants are largely used as agricultural fertilizer. They are far less aggressive chemical compared to the plants as liquid manure; nitrogen availability is higher and less intensive smell.

THE DEVELOPMENT OF BIOGAS-PLANTS IN GERMANY

The cultivation of renewable raw materials to biogas in Germany risen from 400,000 ha in 2007 to 530,000 ha in 2009 [*Fachagentur achwachsende...* 2009]**.** The number of installations, as well as the installed electrical capacity has also risen strongly in recent years. A comparatively high rise can make valid since 2004 first amendment of the renewable energies act (EEG). The number of plants was in 2004 before the amendment still 2010, there were plants in Germany 2005 already 2,690. In 2007 this number has continued to 3,711. The electric power increased from 247 MW in 2004 about 665 MW in 2005 up to 1,270 MW in 2007. As the performance of newly installed equipment is increasing, overall performance increases faster than the number of attachments [F*achverband Biogas* 2007]. In 2009 there were 4,671 biogas plants in operation, producing a total of about 11% of electricity from renewable energy in Germany. At the end of 2011 there where 7,100 biogas plants with an installed capacity of approximately 2,800 MW in operation, according to the power of two large nuclear power plants [*Biogasanlagen ersetzen*…2012].

DEVELOPMENT OUTSIDE OF GERMANY

Due to the large amount of agricultural waste and manure, the Netherlands, Switzerland and Sweden have the most experience with biogas. CHP are used less frequently in those countries. The biogas to biomethane is treated here. In the Netherlands and in the Switzerland it is fed into the natural gas grid. In Sweden, it is used for motor vehicles.

A SHORT OVERVIEW OF THE ECONOMY

For a plant with bio-gas reactor and CHP in the order of 40 kW, as described above, investment costs amounting to arise from 260000.00 Euro (6000.00 Euro/kW) [www.focus.de/finanzen/boerse/biogas-die-ernte-einfahren_aid_435993.html]. With an annual operating time of approximately 8000 hours emerges a energy yield of 320 MWh power. This is composed of 53% electrical (170 MWh) and 47% of heat (150 MWh) energy [*Nahwärmekonzepte* 2007]. After deduction of 20% for required process heat and 5% of the electrical energy for the CHO and the stirrer in the fermenter remains:

– electrical energy = 160 MWh,
– heat energy = 120 MWh.

For heat 0.15 Euros for domestic consumption as well as for the sale can be considered [*Nahwärmekonzepte* 2007]. For the power applies a contract closed for the duration of 20 years with the Government of the Federal Republic of Germany, which guarantees a remuneration of 0.2867Euro/kWh [www.focus.de/finanzen/boerse/biogas-die-ernte-einfahren_aid_435993.html].

So revenues amounting annually to arise for:

– power: 46,000.00 Euro,
– heat: 18,000.00 Euro,

And so far the Total annual Revenue is 64,000.00 Euro.

Costs as ongoing operating costs for personnel, maintenance and repairs are in the range of 0.012 Euro/kwh for CHP and 2,3% of invest for the fermenter [*Nahwärmekonzepte* 2007].

Costs for depreciation for the time of 20 years (there is a good reserve because the fermenter will surely run more than 50 years) are so far 13,000.00 Euro per year.

So we have annual costs for :

– CHP = 1,920.00 Euro,
– biogas reactor/fermenter = 5,980,00 Euro,
– depreciation = 13,000.00 Euro,
– imputed interest = 13,000.00 Euro,

And so far the annual total costs are 33,900.00 Euro. It remains an annual surplus of 30,100.00 Euro.

It is a really interesting result for the farmer income at the interest rate of 11.6%. The investment pays for itself in about 9 years. In addition, the farmer can take funding programs of the EU and Germany with low-interest loans and non-refundable grants.

CONCLUSIONS

With combined biogas plants, as described above, can be made a significant contribution to stop global warming. You can save 85-90% of greenhouse gas compared to fossil fuels with biogas and combined heat and power energy. Such a system, as it can be operated from a farm, results in a saving of 2,300 tons/year of CO_2. A sustainability of our resources secures the future for coming generations. For the farmer, it offers a new and interesting way to generate income. The biogas – technology could expand its contribution to climate protection.

LITERATURE

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Streszczenie

Artykuł przedstawia, w jaki sposób biogazownia może być częścią problematyki zrównoważonego rozwoju w agrobiznesie. Na przykładzie Niemiec zostały wyjaśnione główne korzyści oraz skutki dla rolnika i producenta.

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