Ecological evaluation of biogas feedstock from intercrops

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The production of biogas from renewable resources is a common technology for combined heat and power provision. Small scale plants represent de-centralized energy supply for communities and are an important part of regional development and de-central usage of renewable resources.
To avoid conflicts with the food- and feedstock provision the usage of main crops as main source for biogas production should be avoided. Intercrops are planted on agricultural fields between the periods for main crops and may be used to provide biogas feedstock fields besides main crops. This biogas can be used in decentralized biogas units to produce electricity and heat. Beside the energetic usage of intercrops possible positive side effects are analysed. The usage of intercrops instead of mulching has a potential to decrease emissions of nitrates to water and nitrous oxide to air. Especially emission reduction of nitrous dioxide, a potent greenhouse gas, is part of the analysis.
For the calculation of environmental effects of agriculture with intercrops the ecological evaluation method of the Sustainable Process Index (SPI) is used (Narodoslawsky et. al., 2008).

1. Introduction

Intercrops are planted beside main crops e.g. wheat, corn or triticale between the main crop periods. Intercrops however can also be used to increase yield per hectare besides improving soil quality. Intercrops have the potential to increase biological nitrogen fixation and rebuilding of humus. This would decrease usage of mineral fertilizers which results in a lower ecological pressure. Taking intercrops from the field may decrease this positive effect. This has to be balanced with the potential positive impact of providing energy from intercrops, if they are to be used as substrate for biogas production. For an economic analysis of different possible biogas production scenarios the well known method of the process network synthesis (PNS) (Friedler et. al., 1995; Halasz et. al., 2005) is used. PNS is able to calculate different concepts of using fields most efficiently and also indicate if biogas should be used centralized or decentralized based on economical values.

2. Process Network Synthesis (PNS)

Process Network Synthesis is a method to find an optimal technology pathway out of a complex technology network (maximum structure). The main aim is to find a network consisting operations of processes technologies to transform raw materials into products (including energy). This method allows the optimization of process structures as well as energy and material flows. Time dependencies like resource availability (e.g. harvesting of renewable resources) as well as product or service demand (e.g. varying heat demand for district heating over the year) are part of the optimization. The input necessary for this optimization includes mass and energy balances, investment and operating costs for the technologies considered, costs for resources and utilities, prices for products and services as well as constraints regarding resource supply and product/service demand.

3. Intercrops

To get raw data about soil effects a set of intercrops combined with common main crops are planted on 3 different locations in Austria. Climatic differences between the locations are used to get specific yield data for planting different kind of intercrops. One target is to increase economic output per hectare and simultaneously improve soil quality through intercrops.

Typical planting rotation is to grow the winter type of main crops (e.g. wheat, rape, etc.) and after harvesting the regeneration period starts. This period is used to plant intercrops. Decreasing effects of soil erosion, loss of nitrate and simultaneously increased yield per hectare and year are an argument for planting intercrops. After the intercrop period the main crop period starts again instead of taking a break between the main crop phases without planting anything on the acre.

4. Case study

Figure 1 illustrates a case study from Bad Zell in Upper Austria. Three different fields are used to produce main crops and intercrops. Located in the middle is a village with a demand for district heating.

For the PNS optimization several scenarios are included:

I. Three decentralized biogas fermenter including combined heat and power (CHP) unit selling electricity to the grid and providing heat for the each fermenter
II. The same case like above including transport of heat through district heating pipelines to the village for selling the heat.
III. Three decentralized biogas fermenter without CHP unit with the possibility to transport the biogas (through a biogas pipeline) to one of the others including a CHP unit or to transport it to the central CHP unit. In this case investment costs are lower for a fermenter but an additional heating for the fermenter is required and a little amount of electricity is required from grid
IV. Centralized CHP unit (with a higher capacity) receives the biogas from pipelines and produces electricity and heat. Electricity for the grid and heat for the village through district heating grid to increase the revenue

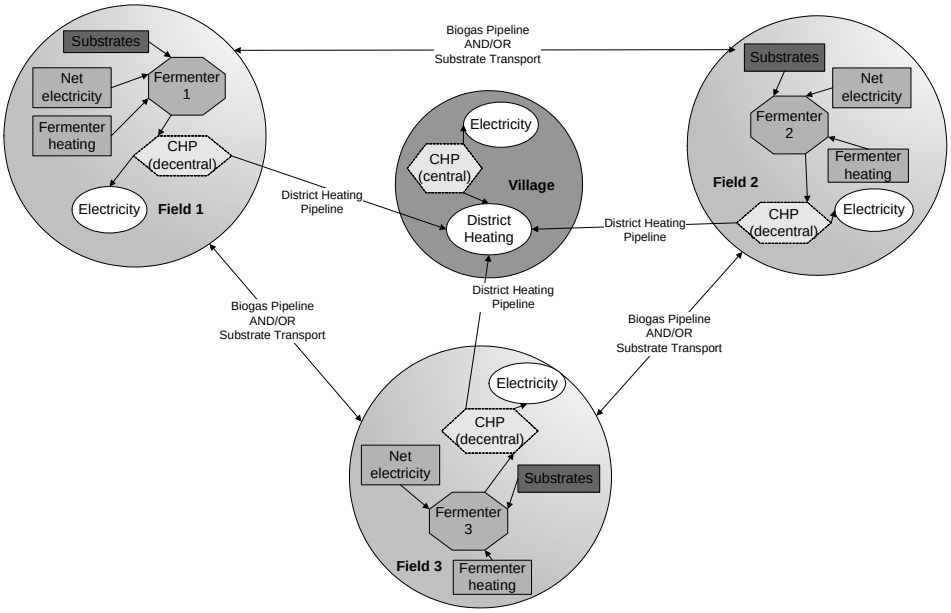

Fig.1: PNS - Maximum Structure

All available scenarios are part of the maximum structure. PNS is used to get an optimized structure out of Figure 1 with the highest revenue. Geographic Information (e.g. distances between fields) is taken into account through different transport prices for each route.

5. Outlook

PNS is used in a different context compared to previous projects. Focus of the optimization is not to identify a pathway through a huge set of different technologies which are producing heat or electricity. Instead this case study PNS optimisation will give answers to following questions:

- Is it better to transport raw materials or products?
- At which transport distance (field-to-field and/or field-to-village) will be the breakover point between centralized CHP and decentralized CHP production?
- Are biogas pipelines economic feasible?

Connected to different PNS scenario results ecological evaluation will be made with the SPI method. This should give us the best scenario in terms of economic and ecologic points of view.
More detailed results will be available till the conference in August 2010.

References

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