Resilient Cropping

1: Growing energy while cycling nutrients on-farm

Biogas production via anaerobic digestion

Introduction

Growing crops specifically for energy production is an expanding industry in several countries around the world. In New Zealand, some research has explored potential crops and has considered the potential for nutrient management and energy production on farm and how they might be integrated.

What is a bioenergy crop? An energy crop is a plant grown with high usable crop dry matter (DM) yield, with low cost and low-maintenance, used to make biofuels, such as biogas or bioethanol. Alternatively, it can be combusted for its energy content to generate electricity or heat. Energy crops are generally categorized as woody or herbaceous plants. Many of the potential bioenergy crops are ones we already grow such as maize, triticale, lucerne, sunflowers, plus newer options such as forage sorghum, Jerusalem artichoke and giant miscanthus.

Growing crops for bioenergy Key factors for successful 'bioenergy to biofuel' schemes include growing crops with high usable crop DM yields with high energy yields per ha of crop. Bioenergy schemes where only parts of the plant are useable (e.g. oilseed crops) generally achieve much lower energy yields per ha compared to systems that can use the whole plant. For non-woody energy crops, **anaerobic digestion** is the most promising conversion technology, which also fits very well within established farming systems.

How? On-farm anaerobic digestion is the most suitable 'rural scale' technology for energy production. It can utilise livestock manure, crop residues, food and processed waste and purpose grown crops. The main component of biogas is methane - a versatile fuel for a wide range of applications. Anaerobic digestion yields at least 3 times more transport fuel than if it was converted to biodiesel.

Uses for biogas Include: 1) vehicle fuel, 2) direct heat use (e.g. for drying, water heating), 3) electricity generation, with or without use of the associated generator waste heat (co-generation) and 4) gas pipeline injection.

Fossil fuel substitution The Closed Loop Nitrogen (CLN) supply cropping system focuses on purpose-grown bioenergy crops, rather than digestion of waste streams or crop residues, with the added advantage of reducing nitrogen fertiliser use. While manure management is already a good reason to build a biogas digester and crop residues are the 'low-hanging fruit' in terms of feedstock cost, the scale of biofuel production needed to replace the energy (mainly diesel) used by agriculture is several times larger than these waste streams alone would provide.

Anaerobic digestion is proven technology and is widely used in European agriculture. Anaerobic digestion plants are common in NZ for municipal waste treatment. Biogas production from NZ crops was demonstrated by MAF Tech in the 1980s.

Use of crops in on-farm digesters is widespread around the world; there are over 7000 anaerobic digestion plants in Germany alone. These are often collectively owned or operated by 10-15 farmers and use bioenergy crops and waste streams from their farms to supply each digester. Many farms have already achieved a high level of energy self-sufficiency with biogas (for heat, electricity and transport fuel) and the uptake continues.

A 200hp tractor running on biomethane, stored in cylinders above the cab (photo courtesy of Biogas plant Margarethen am Moos, Austria).

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Closed-Loop Nitrogen Supply (CLN) cropping system

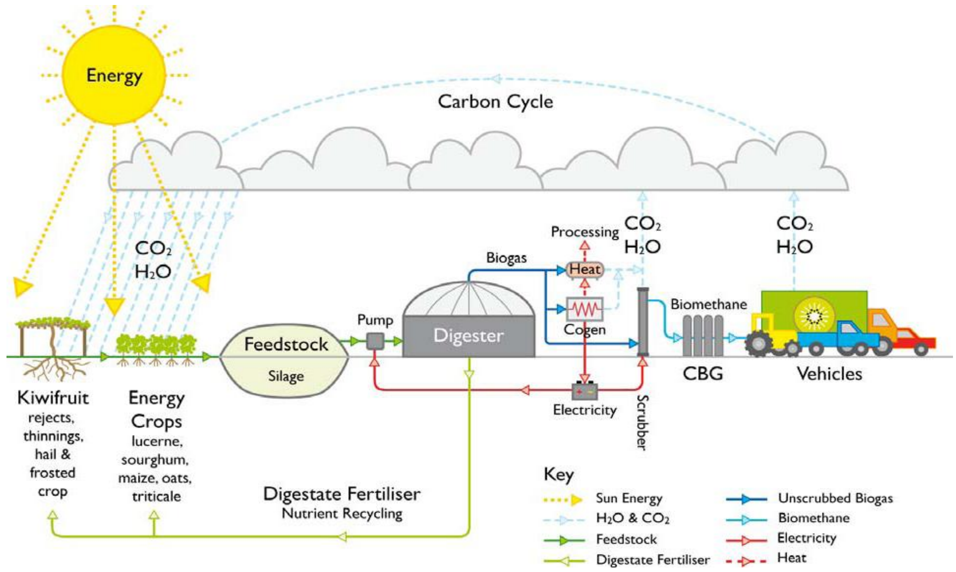

Figure 1. Schematic representation of a closed-loop Nitrogen (CLN) cropping system using anaerobic digestion technology to convert the biomass into bioenergy. The biomass used includes bioenergy crops and crop waste stream. CBG is purified compressed biogas (biomethane). Digestate from the digester is applied as fertiliser back on the farm to grow the bioenergy crops in a closed-loop fashion. In some situations the biogas is used for both electricity generation (and process heat) and biofuel.

Figure courtesy of Loren Poole, Bioform Ltd.

Nutrient cycling

A core component of a sustainable bioenergy cropping system is the ability to fertilise the bioenergy crop with nutrients recycled back to the land with the effluent available from the digester after the biogas is extracted (called digestate). In NZ trials forage sorghum DM yields did not differ when fertilised with digestate compared to synthetic nitrogen fertiliser. Overseas research has also shown that digestate application can reduce soil Greenhouse Gas (GHG) emissions compared to raw effluent and green manure crops. This is in addition to the GHG benefit achieved by substituting digestate nutrients for fossil fuel-derived N fertiliser.

The rural New Zealand opportunity

Currently rural anaerobic digestion start-ups are aimed at manure management. However there is an advantage in terms of biogas yield (and capital pay-back) to co-digest manure with higher gas-yielding crops or residues. Plant and Food Research and NIWA modelled a case study for the Taupo district based on a facility owned by 15 farmers in Austria. Economic analysis using a 220ha mix of suitable crop species, supplying a 3500m^3 digester, found it had the potential to produce a net supply of bio methane equal to 1.27 million litres of diesel per year. Pay-back times for this case study ranged from 2-9 years and were strongly dependent on fossil diesel price. Successful biogas ventures need to be tailored to individual situations.

Some biomass crops are new to growers and biogas production can be a complex enterprise despite extensive practical experience worldwide. Bioenergy production on-farm has potential to provide alternative land use opportunities to substitute renewable bioenergy for fossil fuel derived energy and, as a result, to reduce GHG emissions. Further research is necessary around the economics of production systems and suitable crops for a range of environments.

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