Agricultural crops for biogas production: Publications

1. Introduction

The New Zealand agricultural sector offers significant potential for bioenergy feedstocks using crops, agricultural residues and horticultural residues – ideal inputs for biogas via anaerobic digestion. This approach is already well-established internationally, particularly in the European Union, where countries like Germany operate over 7,000 on-farm digesters. The value of this infrastructure has been underscored by recent disruptions to external natural gas supplies.


Anaerobic Digester

New Zealand is even better positioned than the EU to develop domestic energy solutions, with 3.4 times more agricultural land per capita than more densely populated EU nations. Large volumes of export crop residues – beyond what is needed to maintain and sustain soil life and fertility – remain underutilised. Additionally, converting lower-value arable land and a small portion of pastoral grazing land to dedicated biomass crops is more viable in New Zealand than in the EU or USA, where such practices often face criticism for achieving energy supply at the cost of food supply.

In contrast, an objective assessment of the New Zealand context shows that diversification of pastoral or arable land uses can be beneficial to land management while significantly reducing carbon emissions. Long term contracts between growers of biomass and a new sector of rural processors into biofuels and heat energy could also improve income stability for growers.

Importantly, the foundational research required to support this transition has already been completed. Over a decade ago, studies identified the most promising non-woody plant species for biogas production in New Zealand, along with their dry mass yield potential, crop requirements, regional suitability, biomass storage options and energy potential per hectare.

The key primary research papers, reports and presentations on biomass crops for biogas production in New Zealand are listed below – first as formal citations, each followed by downloadable PDFs in the Bioenergy Association Bioenergy Knowledge Centre (BKC).

2. Publications List (refereed papers, reviewed reports, presentations)

2.1. Refereed science papers

Screening species for Biomass Use in NZ

- **Biomass Gasification Crops for the Climatic Range of New Zealand**. *Renquist AR, Kerckhoffs LHJ (2013)* - Sustainable Agric Reviews 11: 77- 131. Springer Science. doi:10.1007/978-94-007-5449-2_5. [**Note:** This is a chapter in the book format used by SAR]. Download here

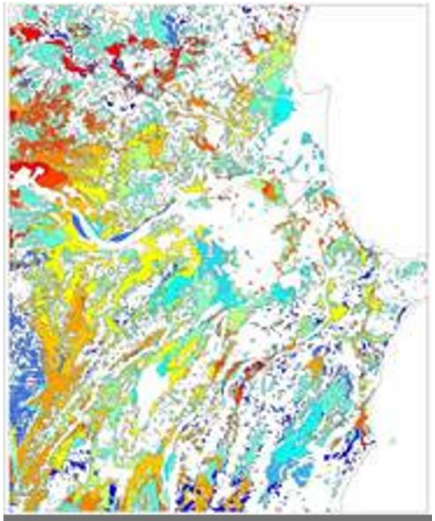
- **Biofuel from plant biomass.** *Huub Kerckhoffs & Richard Renquist (2013)*. Agronomy for Sustainable Development 33:1–19. INRA, France. DOI 10.1007/s13593-012-0114-9. [**Note:** This is a shortened edited version of the *SAR* book chapter, in a more accessible journal]. [Download here]

The Closed-loop Nitrogen Cropping System (CLN)

- **Closed-loop N cropping system: new land uses to make rural biofuel -** *Renquist, R, Kerckhoffs, LJH, Heubeck, S. 2013*. Agronomy NZ 43: 107-122. [**Note:** The two most promising species identified for biogas feedstock were Jerusalem artichoke stems – suitable for Hawke's Bay and regions further south and forage sorghum, ideal for warmer regions including Hawke's Bay and areas to the north]. Download here

Identifying the most appropriate NZ locations for CLN biomass cropping

- **The potential of anaerobically digested crops to supply New Zealand rural fuel requirements.** *Trolove, S, Kerckhoffs L.H.J, Heubeck S, and Renquist R. 2013*.: Agronomy New Zealand 43: 97-105. [**Note**: Part of the CLN project for MPI, this study began with a land use capability mapping analysis, followed by crop modelling using site-specific yield potential and dry matter yields. Heretaunga Plains examples of content such as models and colour maps can also be found in the MPI Information Paper 2014/10, Appendix 6. It also estimated biomass availability and corresponding biogas and biomethane production, aiming to determine how much 'marginal' (summer-dry) land across New Zealand's cropping regions would be needed to meet the country's total rural fuel energy demand. The result: just 5% of that land would be sufficient]. Download here



Crop/land use suitability map

Biomass yield using biogas digestate fertiliser; also CLN methane production per ha of crop biomass

- **Methane production from biofuel crops grown in New Zealand -** *L.H.J. Kerckhoffs, S. Trolove, S. Heubeck and R. Renquist. 2014 :* Agronomy New Zealand 44: 49-60. [**Note:** Part of the CLN research findings presented to MPI, this work involved laboratory analysis of methane yields from ensiled biomass samples, carried out by our collaborators at a specialised biogas lab in Austria. Experiment 3 in Hastings compared sorghum biomass yields when fertilised with biogas digestate biofertiliser versus conventional ammonium sulphate]. Download here

2.2 Reviewed Reports

The Closed-loop Nitrogen Cropping System (CLN)

- **Biogas fuel from a closed-loop nitrogen supply cropping system -** *Kerckhoffs, H, Trolove S, Heubeck S, Renquist, R, 2012*. New Zealand Ministry for Primary Industries. Information Paper 2014/10. [**Note:** This is the final 88-page report to the research funder, MPI detailing the successful development of the CLN system, with colour photos of crop species and representative land capability maps]. Download here

- **Growing energy while cycling nutrients on-farm: Biogas production via anaerobic digestion - Factsheet 1 for Resilient Cropping series -** *Renquist R. 2013* : Funded by Foundation for Arable Research, Horticulture NZ, Tahuri Whenua, MPI and LandWISE. Download here

- **Crops for bioenergy production – An exciting new option: Sustainable Bioenergy Cropping Systems - Factsheet 2 for Resilient Cropping series -** *Renquist R. 2013* : Funded by Foundation for Arable Research, Horticulture NZ, Tahuri Whenua, MPI and LandWISE. Download here

Life Cycle Assessments (LCA) of non-woody biomass species in NZ

[**Note:** These items are research reports, not refereed. LCA analysis was not funded within the MPI project on biogas from the CLN cropping system, however, it was done in a parallel research project on biomass for gasification, which included the two species reported here (R. Renquist); in addition, good results from LCA analysis might be predicted for the very high-yielding warm region species (forage sorghum, forage maize, pearl millet) since their high N fertiliser need can be met within the closed loop CLN system, including the use of legumes].


Jerusalem artichoke

- **Life Cycle Assessment of Jerusalem artichoke (*Helianthus tuberosus*) -** A New Zealand 'Cradle to Farm Gate' assessment of net energy yield, global warming potential and eutrophication impacts of biomass crop production for bioenergy (November 2014). *Renquist, R. 2014.* Confidential Report to Shusheng Pang, leader of the project Biomass to Syngas to Liquid biofuels (BTSL) in the department of Chemical and Process Engineering (CAPE), University of Canterbury, Christchurch, NZ by Bioenergy Cropping Solutions Ltd. [**Note:** The above LCA analysis was done on *H. tuberosus* since the CLN project found it to be the best species to grow in Hawke's Bay and regions to the south for silage, to supply an anaerobic digester for biogas and digestate production]. Download here

- **Life Cycle Assessment of Triticale (*× Triticosecale*) -** A New Zealand 'Cradle to Farm Gate' assessment of net energy yield, global warming potential and eutrophication impacts of biomass crop production for bioenergy (November 2014). *Renquist, R. 2014.* Confidential Report to Shusheng Pang, leader of the project Biomass to Syngas to Liquid biofuels (BTSL) in the department of Chemical and Process Engineering (CAPE), University of Canterbury, Christchurch, NZ, by Bioenergy Cropping Solutions Ltd. [**Note:** *× Triticosecale* is the highest biomass-yielding cereal grain, so the LCA study was made to compare a conventional crop to *Helianthus tuberosus*. Triticale has higher inputs than Jerusalem artichoke, so LCA looks less favourable. However, as an annual species, its total DM yield could be increased if grown in CLN fashion with a legume intercrop. Download here
- **Life Cycle Assessment and Synchrony of Supply of Three Biomass Species: Giant Miscanthus (*Miscanthus × giganteus*), Triticale (× *Triticosecale*) and Jerusalem artichoke (*Helianthus tuberosus)***. *Renquist, R. 2014***.** Confidential Report to Shusheng Pang, leader of the project Biomass to Syngas to Liquid biofuels (BTSL) in the department of Chemical and Process Engineering (CAPE), University of Canterbury, Christchurch, NZ, by Bioenergy Cropping Solutions Ltd.

2.3 Presentations


Sorghum

- **Bioenergy cropping and nutrient cycling -** A presentation by R Renquist at the Bioenergy Association workshop 'Unlocking additional revenue from traditional rural land use – integrating forestry, biomass crops and bioenergy products' held in Taupo, New Zealand on 16 May 2013. Download here
- **Closed-loop N cropping system: new land uses to make rural biofuel.** *Renquist, Kerckhoffs, Heubeck, 2013.* Presented to the 2013 NZ Agronomy Society Conference by S Heubeck. Download here
- **Methane production from biomass crops grown in NZ.** *Kerckhoffs, LHJ, Trolove, S, Heubeck, S, Renquist, R, 2014.* Presented to the New Zealand Agronomy Society Conference 2014 by LHJ Kerckhoffs. *[**Note:** The pdf file will be made available as soon as possible]*
- **The potential of AD crops to supply NZ rural fuel requirements.** *Trolove, S, Kerckhoffs, L.H.J., Heubeck, S., and Renquist, R. 2013*. A presentation to the New Zealand Agronomy Society Conference 2013 by S Trolove. Download here

2.3 Workshops

- **Workshop: Rural Biofuels – A new land-use opportunity for a greener New Zealand.** *Kerckhoffs, H., S. Heubeck, S. Trolove, P. Brown, Z. O'Brien and R. Renquist (2012).* Held 19 June 2012 at the New Zealand Clean Energy Centre, Taupo.

Workshop presentations by the CLN Project Team

- Huub Kerckhoffs CLN cropping. Taupo Workshop. Wshop 120619. Held 19 June 2012 at the New Zealand Clean Energy Centre, Taupo. Download here
- Stephen Trolove Regional Scale CLN. Taupo Workshop. Wshop 120619. Held 19 June 2012 at the New Zealand Clean Energy Centre, Taupo. Download here
- Stephan Heubeck Future Fuels. Taupo Workshop. Wshop 120619. Held 19 June 2012 at the New Zealand Clean Energy Centre, Taupo. Download here

3. Acknowledgement

The collation of this list of research reports is thanks to Rocky Renquist.