Bioenergy Cropping Solutions Ltd

The New Zealand Institute for Plant & Food Research Limited

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

CLN Cropping System for Rural Biofuel

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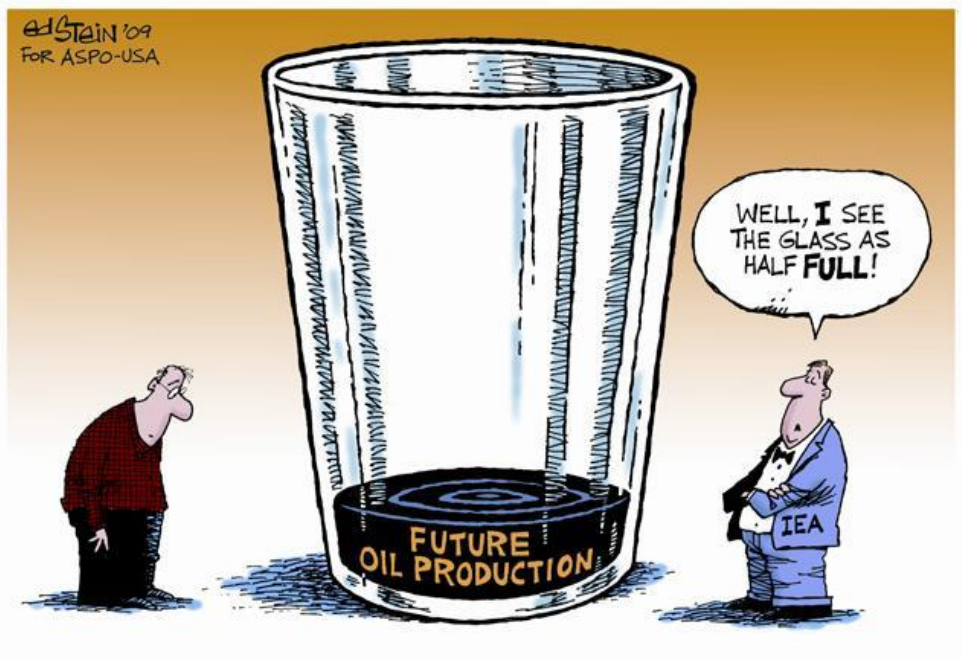
Background

Underlying drivers for the CLN system:

- Traditional farming methods questioned:
  - Climate variability – more droughts
  - Water protection – nutrient caps
  - Land protection – erosion
  - Economics - risk diversification

Source: NIWA, Dave Allen

- Problems around fossil fuel use:
  - GHG emissions
  - Increasing environmental cost
  - Link to fertilizer cost
  - Increasing supply and political risk
  - Monetary cost:
    direct & national economy



Background

The national cost of fossil fuel use:

	Exports of main commodities				Imports of main commodities		
	Commodity	12 months ended September			Commodity	12 months ended September	
		2012	2013 P			2012	2013 P
		$(million)				$(million)	
1	Milk powder, butter, and cheese	**11,828**	**11,473**		Petroleum and products	**8,388**	**7,941**
2	Meat and edible offal	**5,131**	**5,237**		Mechanical machinery and equipment	6,043	5,931
3	Logs, wood, and wood articles	**3,061**	**3,671**		Vehicles, parts, and accessories	5,027	5,612
4	Crude oil	1,957	1,568		Electrical machinery and equipment	3,918	3,842
5	Mechanical machinery and equipment	1,766	1,533		Textiles and textile articles	2,122	2,134
6	Fruit	1,614	1,472		Plastic and plastic articles	1,708	1,798
7	Fish, crustaceans, and molluscs	1,378	1,350		Optical, medical, and measuring equipment	1,352	1,405
8	Wine	1,205	1,234		Iron and steel, and articles	1,267	1,265
9	Electrical machinery and equipment	1,159	1,081		Pharmaceutical products	1,121	1,129
10	Aluminium and aluminium articles	1,084	953		Paper and paperboard, and articles	927	927
11	Preparations of cereals, flour, and starch	836	940		Furniture, furnishings, and light fittings	687	755
12	Casein and caseinates	903	869		Aircraft and parts	1,140	742
13	Precious metals, jewellery, and coins	820	862		Food residues, wastes, and fodder	610	741
14	Iron and steel, and articles	956	845		Fertilisers	**793**	**620**
15	Miscellaneous edible preparations	705	773		Miscellaneous edible preparations	587	618
16	Optical, medical, and measuring equipment	670	770		Rubber and rubber articles	613	594
17	Wool	749	715		Other chemical products	510	486
18	Wood pulp and waste paper	612	606		Beverages, spirits, and vinegar	464	485
19	Raw hides, skins, and leather	568	593		Preparations of cereals, flour, and starch	461	481
20	Textiles and textile articles	585	553		Toys, games, and sports requisites	476	454
	All merchandise exports	**46,748**	**46,019**		**All merchandise imports**	**47,640**	**47,556**

Source: www.stats.govt.nz

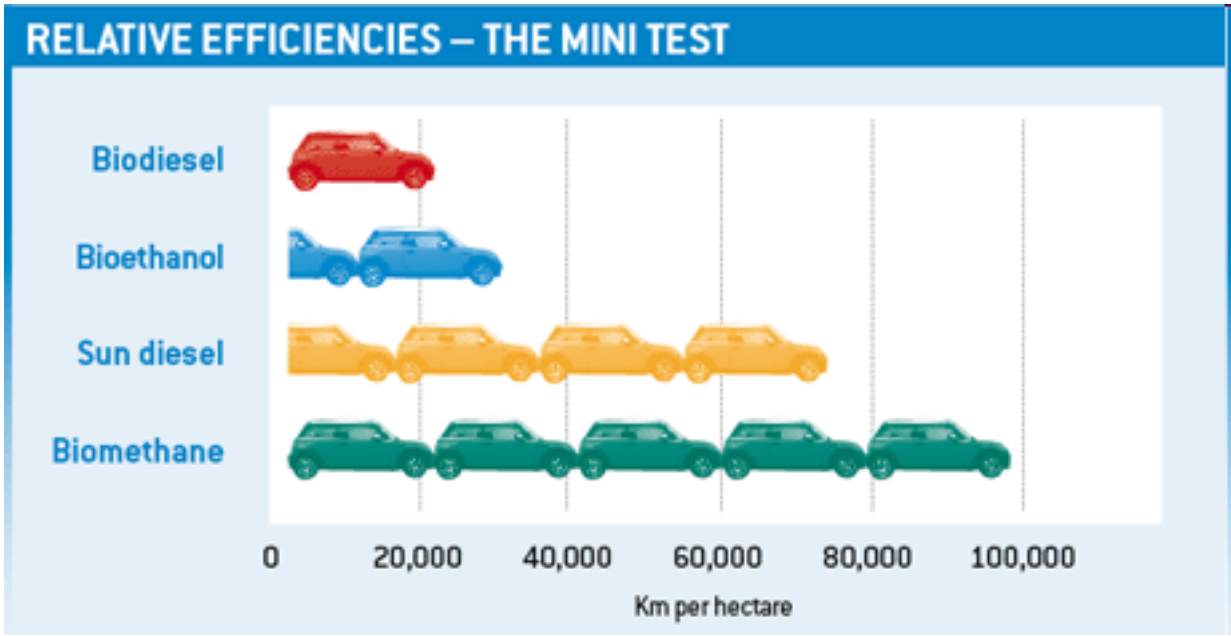
Background

Basic principles of the CLN concept:

- Use some of the increasingly harder to farm land to “grow” transport fuel
- Find scale that matches rural requirements
- Aim for sector self-sufficiency, not cash exports
- Close nutrient loop
- High areal productivity
- Moderate complexity

One of the best options:

- Biogas



Source: www.biodieselnow.com/forums/t/19315.aspx

Biogas

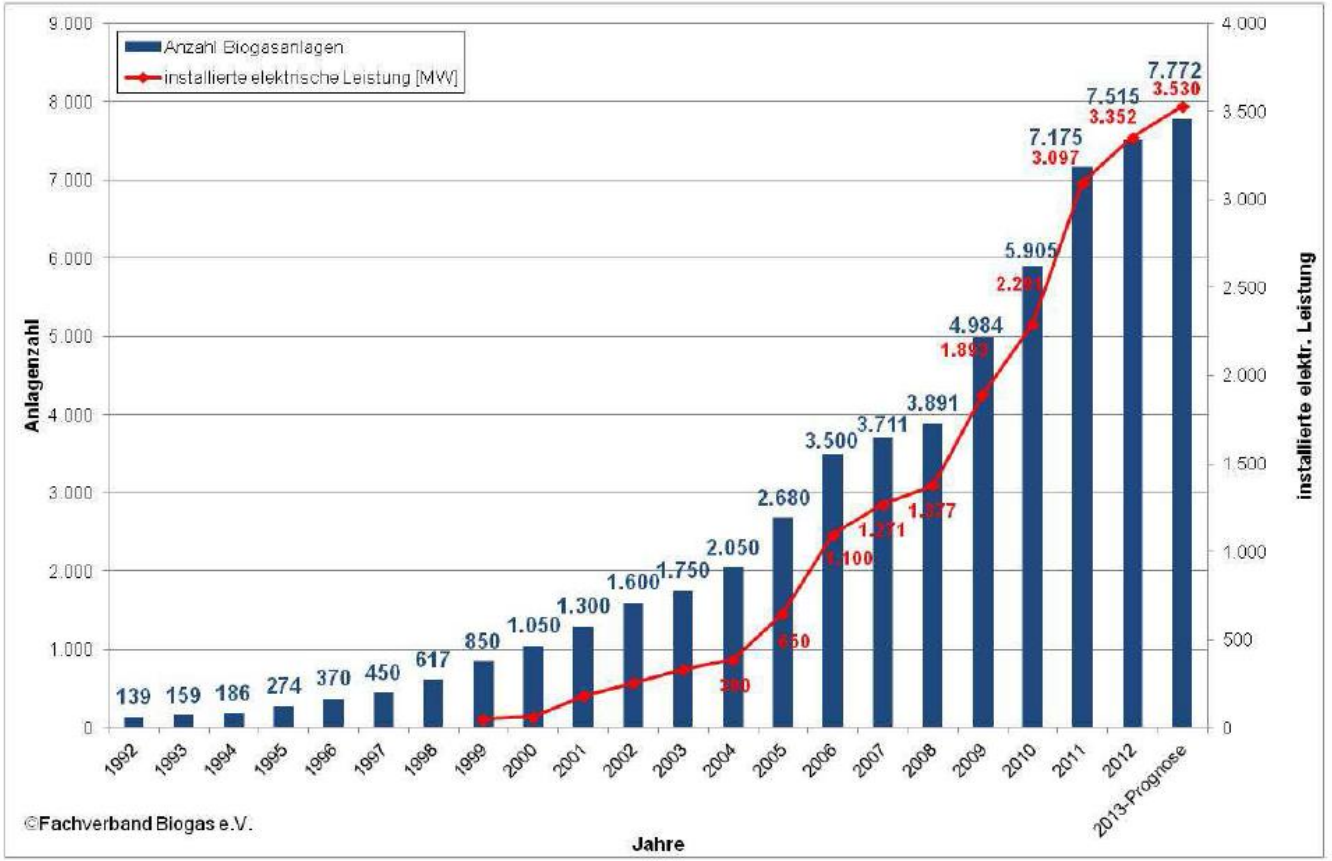
The most versatile renewable energy resource

Source: http://www.envitec-biogas.de

Biogas

Biogas is an established technology:

- > 7,500 rural biogas plants in Germany
- Austria, Sweden, France, Italy also major players



Graph:
Number and installed electricity generation capacity (MW) of biogas plants in Germany

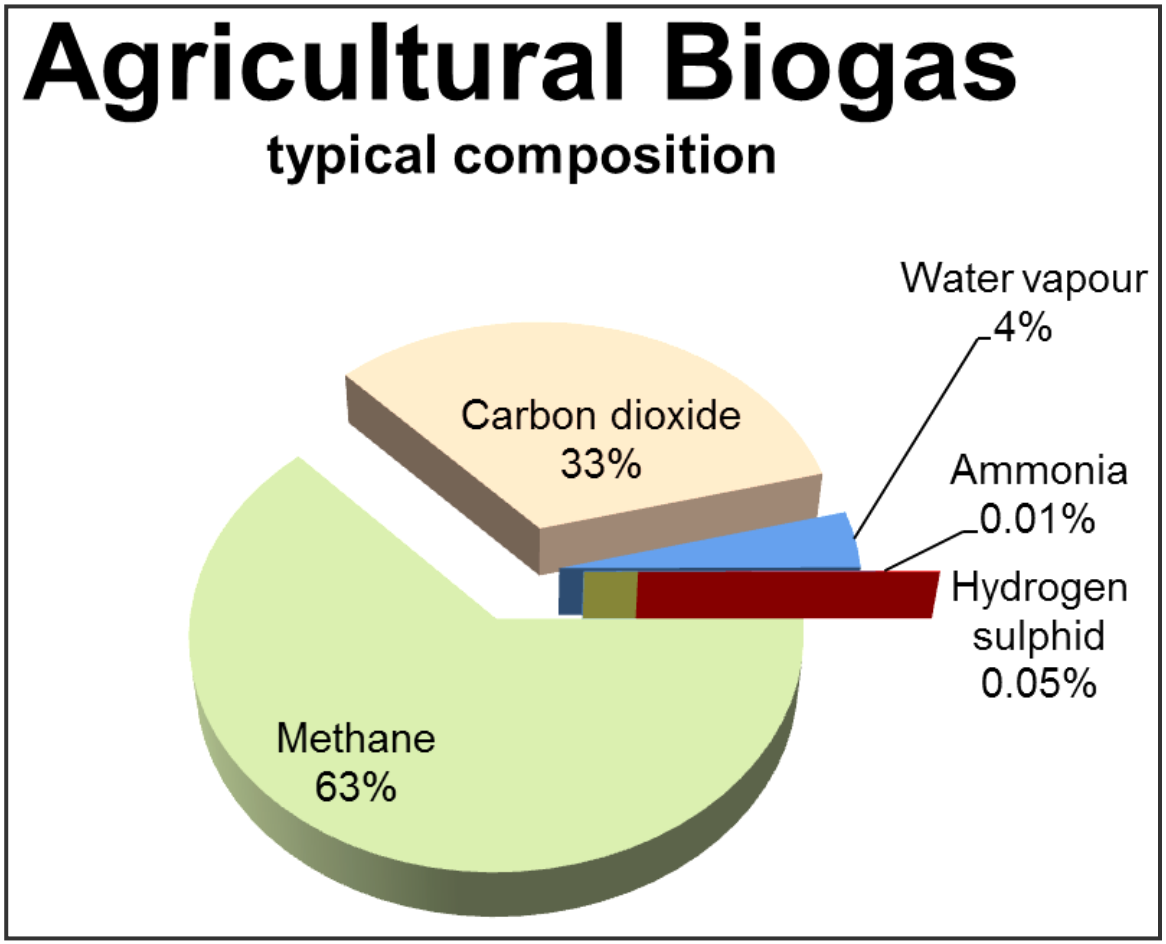
Source: Fachverband Biogas e.V. (German Biogas Association)

Biogas

Biogas is a mixture of gases:

- Composition may slightly vary
- Properties
  - Similar to natural gas
  - Corrosive impurities
  - Lighter than air
  - Calorific value:

    ~20MJ/m^3



Biogas use options

- Biogas can be used for electricity generation or as boiler fuel
- Biogas transport fuel:
  - Purified and compressed biogas (bio-methane) can be used in any CNG vehicle, however heavy vehicles have economic and logistic advantages
  - Highest financial and ecological value for biogas use
  - Chicken and egg problem building up production facility and user fleet in parallel ➔ minimum size: ~500L/day?

Biomass Cropping Aims

- Produce a biofuel that can be made with local scale technology and has a high fuel yield per ha: *biogas*.

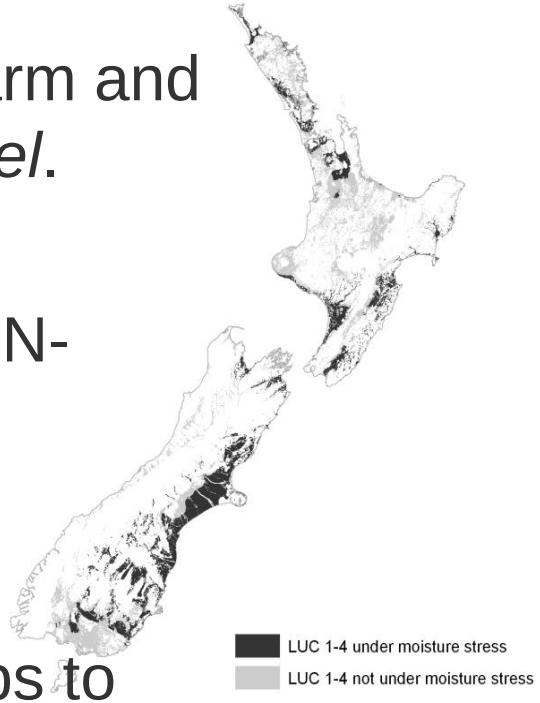
- Demonstrate a cropping system in which bioenergy crops are fertilised with *recycled crop nutrients*:

  the Closed-Loop N system (CLN).

- Identify the best species, those with sustainable high biomass yield, adapted to sites that are often ‘summer dry’ and that fit into the resilient CLN cropping system

Rural benefits

- Substitution of fossil fuels used on the farm and by rural trucking with local, reliable *biofuel*.
- Little need for purchased fertilisers: Use N-efficient crops plus legumes and recycle nutrients.
- New land use opportunity: to supply crops to biofuel producers. Use ‘marginal’ sites where other crops are susceptible to moderate drought stress.



Forage sorghum (‘Jumbo’)

‘Jumbo’
Sorghum

Kerikeri
2010

2.5m tall
at leaf top

30 tDM/ha

Forage sorghum (‘Jumbo’)

Bioenergy Cropping Solutions Ltd

‘Jumbo’ Sorghum

Hastings 2011

2.5m tall leaftop

27 tDM/ha

Jerusalem artichoke, tubers

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Jerusalem artichoke (JA)

JA as an annual crop (first year plantings) in Hastings

Shoot biomass
200 days after planting:

<u>2012</u>
31 tDM/ha

<u>2013 (no rain)</u>
16 tDM/ha

Jerusalem artichoke (JA)

JA as a perennial crop;
(second year)

Shoot biomass
190 days after emergence
in Hastings:

<u>2012</u>
26 tDM/ha

<u>2013 (no rain)</u>
17 tDM/ha

Cropping Conclusions

- The most promising combinations of new biomass species and legumes to maximise biomass production for biogas on 'summer-dry' marginal land:

  (1) forage sorghum in combination with tickbean or crimson clover (Hawke's Bay & north)

  (2) Jerusalem artichoke and/or lucerne (H. Bay south)

- Our biomass crop yields in good sites:

  forage sorghum 20-25tDM/ha + 10tDM/ha for legume

  Jerusalem artichoke 16-25tDM/ha

  Lucerne 16-22 tDM/ha (3-4 cuttings)

  (all are well adapted to the CLN system)

Farmer group scenario

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From the farm – for the farm

- Based on example Margarethen am Moos – Austria
- 12 Farmer co-operative
- Biogas plant for manure and energy crops from 220 ha
- 625 kW electricity generation – base load
- Waste heat for half the village
- Vehicle fuel station for cars, vans and 2x 200 HP tractor
- Truly on the way to energy independence

Farmer group scenario

Bioenergy Cropping Solutions Ltd

Base assumptions:

- 12 farmer co-operative – Lake Taupo area
- 220 ha biogas cropping area
- 2 ha average plot size
- 18.3 ha average land contribution per farm
- From 8 to 45 ha contribution per farm

Farmer group scenario

Crop composition:

- 5,045 t DM/year
- 16,825 t FM /year

JA	90ha
Triticale	70ha
Sorghum	20ha
Maize	20ha
General pasture	20ha
Crimson clover with triticale	*70ha*
Vaba beans with Sorghum	*20ha*
Vaba beans with maize	*20ha*
Crimson clover with triticale	*70ha*

Farmer group scenario

Annual yields:

Biogas	2,645,376 m³/y
Methane	1,440,853 m³/y
Digestate	13,389 m³/y
Generator elect. output (by-product)	1,314,000kWh/year
Methane available for transport fuel	1,065,424 m³CH4/y
L diesel equivalent	953,274L diesel equi/y

Farmer group scenario

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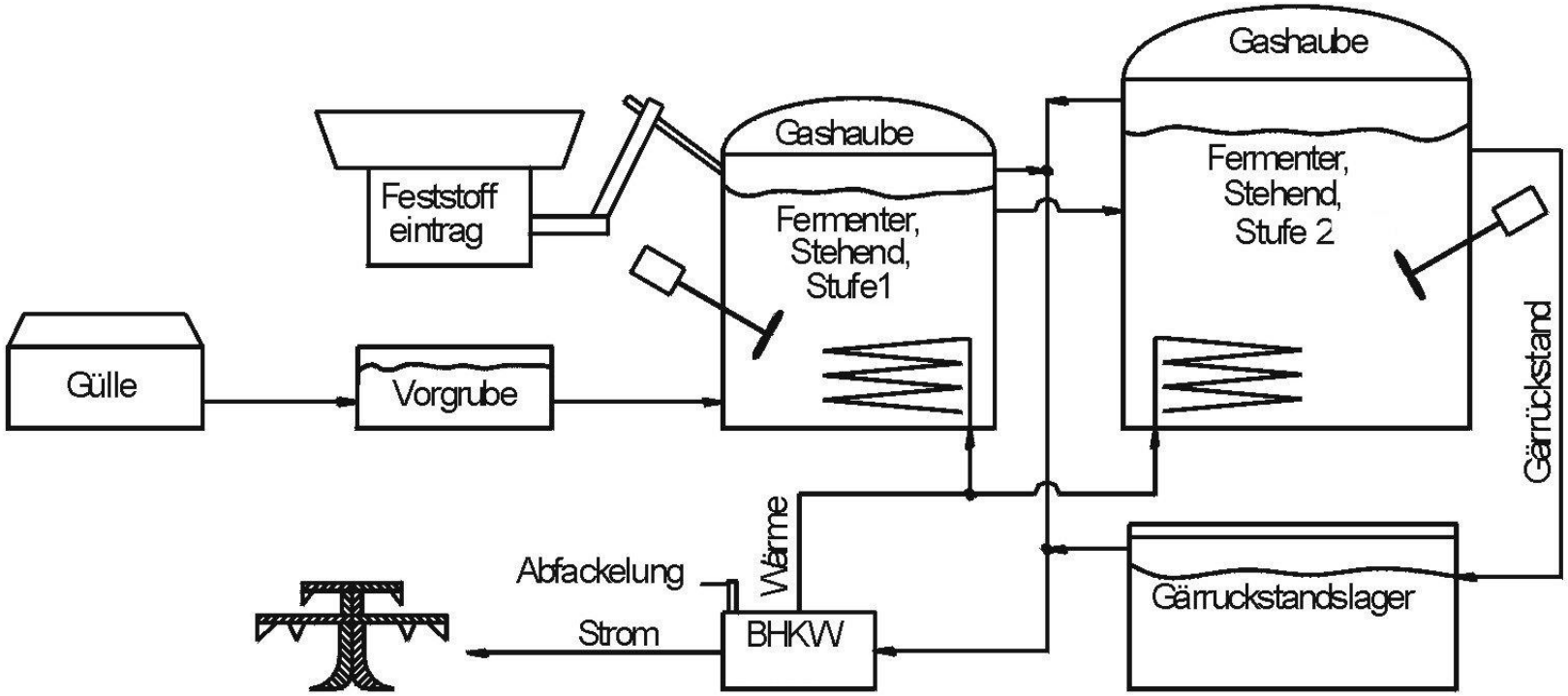
Required biogas plant:

- 3,500 m3 main fermenter volume
- CAPEX and OPEX cost from KTBL online database
- Straight (0.6) Euro to NZ$ conversion



Farmer group scenario

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Key economic figures:

Approx. electricity price (export, own and plant use)	$	0.11 /kWh
Electricity earnings	$	144,540.00 /y
Diesel substitution price	$	1.50 /L
Diesel substitution earnings	$	1,429,911.73 /y
Total earnings	**$**	**1,574,451.73 /y**
Substrate costs	$	789,708.33 /y
Annualized equipment costs	$	181,167.45 /y
Annual interest costs	$	85,734.03 /y
Other variable costs	$	106,312.78 /y
Total costs	**$**	**1,162,922.60 /y**
Annual "gross profit"	$	411,529.13 /y
Biogas plant payback period		**2.8 years**

Farmer group scenario

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Key economic figures:

- Rather acceptable economic returns
- Fishhook: very large dependency on diesel price
  - E.g. at NZ$ 1.90 / L ➔ 1.8 years payback period
  - E.g. at NZ$ 1.00 / L ➔ 9.4 years payback period
- How realistic are our assumptions?

- Not too bad: German network authority finds in June 2012 with a survey of 77 biogas to transport fuel (gas network) plants a break even point (incl. substrate) of ~ NZ$ 0.90 / L diesel equivalent (5.7 cent/kWh).

Farmer group scenario

Where is scope for such concepts in NZ:

- As a further alternative in locations where traditional land use is challenged, i.e. invasive weeds, nutrient sensitive areas (Taupo), draught areas
- Where complex waste management is part of the mix
- Where energy autonomy based on renewables has additional value, i.e. tourism areas, Maori communities
- In a crisis situation, or wherever the fast start, moderate scale of the concept provides particular advantages

Rural NZ Biofuel potential

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Stay tuned for Stephen Trolove

NIWA
Taihoro Nukurangi