GHG reduction using biogas technologies

1. Introduction: Green House Gas reduction and Biogas

The NZ Greenhouse Gas (GHG) inventory accounts the global warming potential (GWP) of one tonne of methane as 25 times that of 1 tonne of fossil CO_2. Methane is produced from organic matter placed in landfills, waste water treatment facilities, and decaying agricultural and food processing organic residues. Removal of methane emissions is therefore a key greenhouse gas mitigation opportunity.

The waste sector produces mainly methane emissions (96.4%)[1]. There are significant additional emissions of CO_2 from disposal of solid waste but these are of biogenic origin and are not reported.

In 2013 there were 49 landfill sites and 367 waste water treatment facilities and emissions from the waste sector contributed 5,054 kt CO_2-e or 6.2% of NZ's total greenhouse gas emissions.

Table 1: Greenhouse gas emissions from waste

Source	2013 emissions[2] (kt CO_2-e pa)	%
Solid waste disposal	4600.3	91
Biological treatment	0	0
Incineration	3.1	0.06
Wastewater	450.5	8.9
TOTAL	5054	

23 landfill sites had operational methane recovery systems (17 operating and 6 closed sites). These 24 sites accounted for 84% of waste disposed to municipal landfills. The 25 smaller sites have no methane recovery system. 68% of methane produced is recovered at sites where gas is collected, and over all landfill sites 40% of methane is collected. Most municipal landfills accept locally produced industrial waste as well as municipal waste.

Most municipal landfills are mandatory participants in the NZ ETS with obligations to report and surrender emission units for their methane emissions

Table 2: Estimated composition of waste to municipal landfills in 2013

Food	Garden	paper	Wood	Textile	Nappies	Inert
17%	8%	11%	12%	6%	3%	44%

[1] . Source New Zealand's Greenhouse Gas inventory 1990-2013, Ministry for the Environment
[2] Net emissions after methane recovery. In 2013 1354.25 kt CO2-e methane was recovered.

There are[3] 15 waste processing facilities collecting methane and using it as fuel to generate electricity:

- 11 landfill facilities with 29.4 MW electricity generation capacity. The facilities produce electricity only. Heat is discharged to atmosphere.
- 4 waste water treatment facilities with 11.3MW electricity generation capacity. These are all cogeneration facilities with heat and electricity all consumed on-site for the processing of sewage.

In 2013 waste water treatment and discharge contributed 450.5kt CO_2-e of emissions from the waste sector (8.9%).

Domestic and commercial wastewater contributed 254.5kt CO_2-e (56.5%) of emissions from 317 municipal wastewater treatment facilities and approx. 50 government or privately owned treatment plants. Although most of the wastewater treatment processes are aerobic there are a significant number that use partially anaerobic processes such as oxidation ponds. Small communities and individual rural dwellings are served mainly by simple septic tanks. 10 municipal treatment plant accept large amounts of industrial wastewater.

8 domestic wastewater facilities remove methane via flaring or for energy production resulting in zero methane emissions.

Industrial waste water contributed 196.1kt CO_2-e (43.5%) emissions from wastewater facilities. The major source of industrial wastewater comes from the meat processing, and pulp and paper industries, and dairy processing. Most industrial waste water treatment is aerobic and most methane from anaerobic treatment is flared. However there are a number of anaerobic ponds that do not have methane collection, particularly in the meat industry.

There is no methane recovery from the meat processing, wine, and pulp and paper sources. Since 2012 the wool processing industry has used aerobic treatment of wastewater and thus methane emissions are no longer produced.

The dairy industry predominantly uses aerobic treatment. There is only one dairy processor (Tirau) using anaerobic treatment and the methane is used directly as a heating fuel. Consequently there are no methane emissions from the dairy processing sector.

An estimated 5% of manure from dairy cows is stored in anaerobic lagoons[4].

There are 4 agricultural facilities processing liquid waste through anaerobic digestion plant where methane is collected and used directly as energy:

- 1 piggeries
- 3 dairy farms

Tools to collect the methane and process it so as to avoid GHG emissions and thus avoid the need to surrender emission units are proven and already available in NZ but are presently under-utilized. These processes produce and capture biogas which can then be used to generate electricity; be a source of heat; or used as a replacement fuel in vehicle engines. Once used (burnt), the biogas converts back to carbon dioxide which is GHG neutral, as it is from atmospheric carbon dioxide that had been recently converted to organic matter and is just being re-released.

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[3] As at 31 December 2012. Source New Zealand's Greenhouse Gas inventory 1990-2013, Ministry for the Environment.

[4] Ledgard and Brier 2004

It does not come from long sequested fossil fuels (Oil and Coal) which add more fossilized carbon dioxide to the present total atmospheric GHG inventory. Many of these applications are economic for facility operators when the released energy is used to reduce on-site operating costs.

2. Drivers

The use of biogas technologies to remove methane emissions can have a wide range of drivers, but it is often not until the lifecycle costs and benefits are considered that the collective benefits from the opportunities become economic. (Energy is only one of the benefits and not always the primary driver. Many of these benefits are public goods and not able to be captured by the facility owner/investor). These drivers can include:

- Reduction of GHG from the methane that would otherwise escape from waste treated or disposed of by other means (from landfill in particular) (Affects NZ's ETS position)
- Reduction of the ultimate waste disposal volume and chemical oxygen demand (COD) when finally disposed of back into the environment. (thereby extending disposal facility use (e.g. landfill) and complying with the Waste Minimisation Act)
- Production of energy (biogas, which can be used for heat, electrical energy, cooling, or as a replacement transport fuel)
- Digestate which is a good, stable fertilizer (closes the nutrient loop cycle)
- Reduction of the odours associated with disposal facilities (reducing social unacceptability of disposal facilities)
- Reduction of vermin at disposal facilities (rats, mice, birds, hedgehogs)
- Reduction of disposal facility land instability post facility closure
- Deals with organic wastes accountability with a quick treatment (typically 21 days) as opposed to 20 years or so in disposal facility (long term methane leakage) with consequently much harder accounting for GHG emissions
- Provides employment
- Can provide CO_2 enrichment for horticulture hothouse crops.

As shown in Figure 1 New Zealand is already a world leader in processing municipal solid and liquid waste to energy using anaerobic processes and has the capabilities to cost effectively treble the amount of methane currently collected and processed into energy using proven technologies.

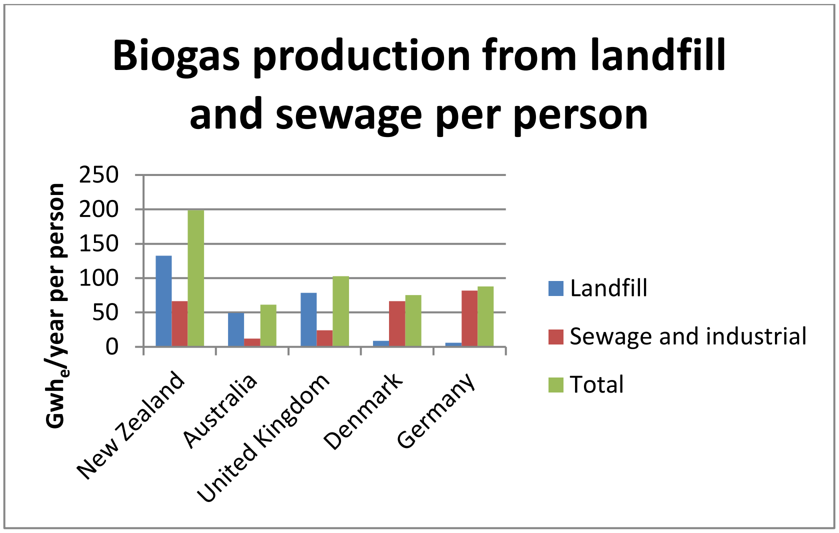

Figure 1: International comparison of municipal biogas production Source; IEA Biogas

3. GHG reduction opportunities

Methane is the major constituent of biogas (between 40 and 70%, the balance is Carbon dioxide).

Biogas is the natural result of organic material decaying in the absence of oxygen (anaerobically) and occurs anywhere organic material is left to rot, particularly in landfills. Landfills provide a large, generally biologically uncontrolled place for the dumped organic material to decay. Piles of organic matter, left untreated will naturally produce methane-containing biogas.

If organic waste from municipal, agricultural and industrial sources is not processed appropriately the methane (CH_4) produced is a much more significant greenhouse gas emission than carbon dioxide (CO_2), by a factor of 25.

Investment in appropriate disposal facilities or waste management/ treatment plant can nearly eliminate the methane discharged into the atmosphere by converting it into CO_2 in an electricity generator, boiler or flare. This CO_2, being of biomass origin, is accounted for as GHG neutral, resulting in an almost complete elimination of GHG emissions from that source. The captured biogas, however, is valuable for the generation of electricity, heat and use as an engine fuel substitute. When the waste is treated in an anaerobic digester to produce biogas, the digestion residue (digestate) is a valuable fertilizer.

3.1 GHG reduction scenarios

The barrier for greater uptake of the use of biogas technologies to reduce GHG from methane appears to be the lack of 'desire to make it happen', and the relative cost benefits of other use opportunities eg composting municipal waste, and distribution of untreated dairy effluent onto pasture. There are no technology barriers. In many situations the lack of desire to make projects happen are because of a lack of access to capital finance.

The focus for the reduction in methane discharge to atmosphere and thus GHG emission reduction is on maximizing the value available from our organic wastes through use of biogas technologies.

The priority areas for methane reduction, in order, are:

1. Food processors and municipal waste water treatment plant operators, who produce organic waste and to economically convert this into biogas for energy, to reduce on-site energy costs.

2. Ensure all significant landfill operations collect and use the landfill gas naturally produced (biogas) and / or maximize the value of the biogas they already collect.
3. Assist agricultural businesses that produce large volumes of organic waste (eg; manure) to process this into biogas for on-site energy use before recycling waste nutrients back to the land.

Three scenarios (Business as usual, Encouraged Growth and Accelerated Growth) show the robustness of the opportunities to reduce methane emissions from organic waste.

3.2 Scenarios

The scenarios for growth in the production and utilization of biogas are:

Scenario 1: Business As Usual (BAU)

Conditions:

- Based on existing policies and market conditions. No policy changes
- Uses existing technologies and an extension of current trends
- No 'maybes'. Only realistic activities based on existing sector participant's activities.
- Assumes current ETS 2 for 1 policy is deleted and the ETS administration is improved, with no other significant changes.

Scenario 2: Encouraged Growth

Conditions:

- Government signals that it wants to encourage domestic mitigation and avoid the need for the purchase of international units
- Based on BAU conditions plus:
  - Limited number of complementary measures pursued and implemented.
  - Central Government introduces policies that change Government procurement procedures so that renewable energy, efficient energy and all additional benefits are included in a full life cycle cost analysis of options.
  - Local councils introduce policies for local government procurement, similar to central Government procurement policies and that these must be considered when making investment decisions.
  - Government adopts a collaborative growth strategy with each renewable energy sector

Scenario 3: Accelerated Growth

Conditions:

- Government seriously considers and adopts some complementary measures to the ETS
- As for Scenario 2 above, plus:
  - Low cost policies introduced to address specific barriers across renewable energy sectors and within each sector.
  - Government does an annual cost-benefit analysis of forward offshore ETS purchase obligations vs acquiring domestic mitigation through a capital fund.

Figure 2 gives the expected additional GHG emission reduction for the three scenarios based on the methane capture scenarios shown in Figure 3.

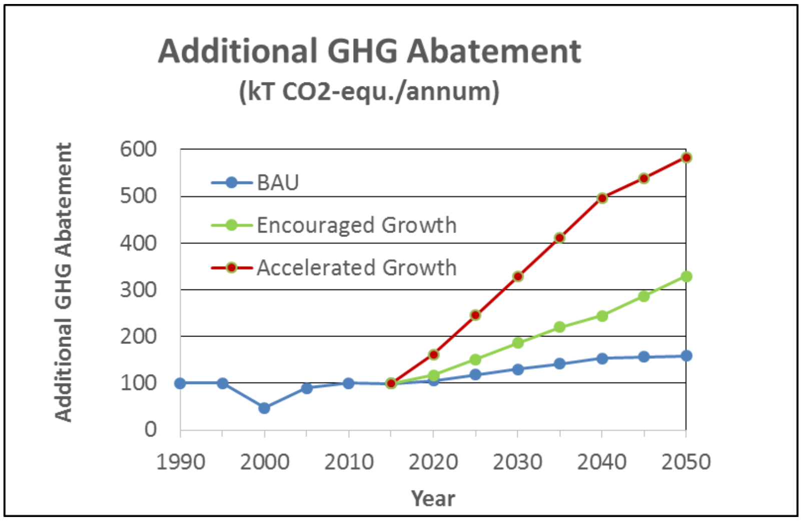

Figure 2: GHG abatement in the 3 scenarios

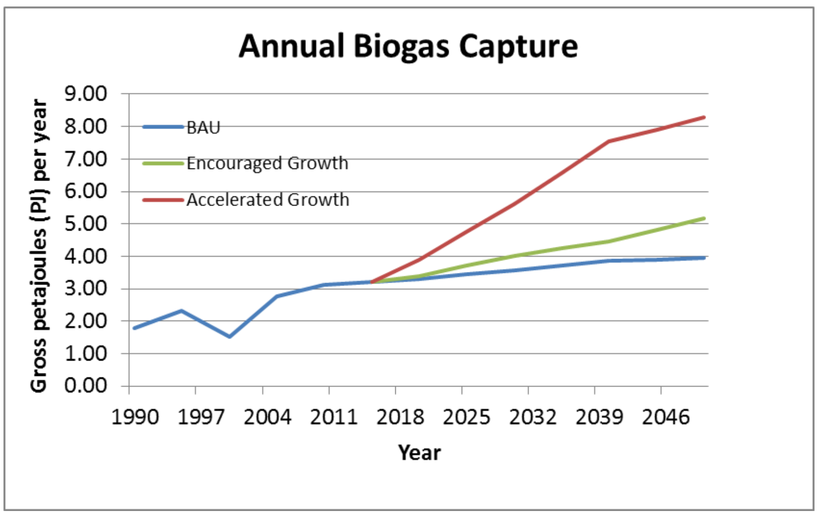

Figure 3: Scenarios for annual biogas capture

Analysis of the opportunities in the liquid and solid waste sectors shows that collectively, by 2050, with encouragement policies, there could be:

For scenario 1-Encouraged Growth:

- A 2 fold increase in the annual waste treatment for production of biogas (refer Figure 2), with a consequent 230 kt CO_2-e per year reduction in emissions compared to 1990 (refer figure 1).

For scenario 2 – Accelerated Growth:

- With the adoption of the appropriate acceleration policies, as set out in section 3, increased waste treatment and consequent biogas production could increase by 4 times, providing a 500 kt CO_2-e per year reduction in emissions, when compared to 1990.

Table 3 shows were methane reduction can come from by 2050.

Methane reduction sources	PJ/annum	%
Electricity, direct use and CO_2 enrichment from landfill gas (biogas)	3.01	36
Electricity, direct use and CO_2 enrichment from dedicated on-site digestion of putrescible industrial waste	1.7	21
Electricity from co-digestion of industrial waste in municipal WWTP	0.9	11
Electricity municipal sludge digestion optimized for energy recovery	0.74	9
Direct use, CO_2 enrichment, or use as vehicle fuel of biogas from WWTP.	0.33	4
New dairy farm uses	1.61	19
Total max methane (from biogas) 2050	8.29	100

Table 3: Sources of methane reduction (2050 Accelerated Scenario)

On a lifecycle costs and benefits basis, the investment cost to facility owners is around zero. Central and local government costs used to encourage methane reduction are estimated at around $200,000 p.a. for 3 years, and for the accelerated methane reduction scenario is estimated to be less that $800,000 p.a. for 5 years, excluding any investment in suspensory loans and the fiscal cost of deferred depreciation.

3.3 Assumptions

The assumptions for the biogas GHG reduction scenarios are that:

- Economies of scale and steady biogas plant operation are achieved by the sourcing of trade wastes, and supplementary feedstocks
- Gate fees for taking trade waste into a waste treatment plant reflect the cost of otherwise disposing/processing of such waste. (eg by landfill)
- Local government encourages separation of organic matter from municipal solid waste in Scenario 2 and requires it in scenario 3.
- There is no new technology and no new anaerobic digestion research needed.
- Existing waste treatment facilities continue to be utilized or upgraded.
- A very high proportion of the current municipal organic waste which ends up in a landfill, will then be disposed of in an anaerobic digester, so capturing and burning the biogas (~60% methane)
- Because discharge of 1t of methane to atmosphere has a 25 times greater global warming potential than 1t of fossil CO2, methane capture and use should will be a logical priority for municipal waste management policies.
- In scenario 2, a target is set for the production, capture and use of methane at waste water treatment plants which provides an incentive to collect and use the biogas for on-site electricity generation, on-site heat utilization and / or use as a transport fuel replacement.
- In scenario 2, landfill operators use a greater portion of the biogas collected for replacement of fossil vehicle fuel.

- GHG emission reductions (CO_2–e) are based on:
  - Comparison to the 1990 discharge of methane from municipal, industrial and agricultural waste to atmosphere
  - On site electricity: the difference between use of methane to generate electricity compared to the discharge of methane to atmosphere and the alternative purchase of electricity from the grid
  - Vehicle fuel: Use of biogas as a replacement for vehicle fuel instead of discharging the methane to atmosphere and the use of fossil fuel (usually diesel)
  - Heat: combustion of biogas in a boiler compared to the discharge of methane to the atmosphere
- Where appropriate in scenario 2 urban bus transport utilizes available biogas from waste water treatment plants as a fuel (biogas then becomes CNG). (eg, as already used by “Go Bus” in Hamilton)
- There are presently only weak GHG drivers for the capture of dairy effluent biogas in scenario 2 and scenario 3. But increasing demands for better farm effluent management for the protection of waterways or odour emissions can result in a moderate increase in the production of biogas for on-farm electricity, heat and replacement of vehicle fuel.

4. Complementary measures

The following measures complementary to the NZ ETS would encourage increased GHG reduction from biogas applications under scenario 2 and 3.

1. **Government, Local Government New Zealand, and Bioenergy Association agree targets to reduce emission from organic municipal and industrial waste by 2020, 2030**.
   - The objective is to encourage the reduction of methane emissions from landfills, waste water treatment plants and industrial processes.
   - The Bioenergy Association, Local Government and New Zealand Government will agree a specific target for the reduction of methane from landfill and waste water treatment plants.
   - EECA and Bioenergy Association, under a Collaboration Agreement, will agree on a strategy and action plan including: target facilities, promotion, education and information programme: value proposition information, collection and dissemination of demonstration project information.
   - MfE to extend the existing mechanism for the collection of data from all landfill and WWTP and to provide an annual report on methane capture and emission presented by region.
   - The Bioenergy Association will assist to achieve the targets by:
     - Establishing a working group with MfE and LGNZ to develop a work programme for methane emissions reduction from waste.
     - Preparation and promotion of regional methane reductions and opportunity plans that provide guidance to the respective organic waste sector suppliers.
     - Collating and publishing useful information from any demonstration facilities into a Technical Guide.
     - Collating information from local govt on their existing policies with regard to methane reduction. Reviewing the information and report back to local govt as a whole with useful information.
     - Hosting regional meetings to assist liquid and solid waste facility owners to be up-to date with methane reduction opportunities and practises.
   - Government to review the present use of the landfill Waste Disposal Levy and the criteria for grant allocations from the Waste Minimisation Fund, so as to include methane emission reduction opportunities.

2. **Central Government introduces procurement policies so that waste to energy or other renewable energy options must be considered when making capital investment decisions and all costs and benefits are included in a full life cycle analysis of options and reasons provided for not adopting a renewable energy solution.**
   - EECA and the Bioenergy Association develop Technical Guides:
     - Methods and evaluation of options for methane collection and processing at WWTP.
     - Methods and evaluation of options for destruction of methane from landfill.
   - Government's project appraisal model uses a CO_2 cost profile assumption published by EECA from time to time. This profile takes account of assumed movement over time as a result of the ETS (This approach/modelling will also demonstrate that the Government is taking clear long term decisions that reflect the likely real price of carbon over the life of the methane-fuelled plant i.e. 20 years plus).
   - Local councils be required to introduce procurement policies similar to those adopted by central Government.
3. **EECA extends the repayment period for Crown Loans**
   - Extend the period of Crown Loans for biogas facilities beyond the current 5 years to better reflect the economic lifecycle costs and benefits of a waste processing facility.

4. **Government introduces policies to allow for accelerated depreciation of renewable energy, waste to energy and energy efficiency capital investments.**
   - Renewable energy and energy efficiency equipment is more capital intensive but often has lower on-going operating costs than alternatives.
   - Access to capital is a major barrier to investment in renewable energy and energy efficiency solutions. Allowance of accelerated depreciation is fiscally neutral to Government except for timing. However accelerated depreciation can provide a significant assistance to plant investors.

5. **Government establishes a GHG Reduction Fund to provide suspensory or low interest loans or similar for renewable energy and energy efficiency capital investments.**
   - Many renewable energy projects may be potentially financially attractive but access to capital is a major barrier. Having provision for suspensory loans which are paid back out of operating profits once the project is operational can assist potential projects get underway.
   - Suspensory loans from central government, or restructured rates schemes at city council level could assist the uptake of this low emission technology.
   - There may be a role for a GHG Reduction or a Clean Energy Fund, similar to that in Australia, to make money available to private sector projects to compliment the Crown loans available through EECA for renewable investment projects.
   - A GHG Reduction Fund managed in the way the NZ Super Fund or ACC manage their funds should be established to make loans, similar to Crown Loans, available to private sector projects.
     The Australian entity, is the Clean Energy Finance Corporation (CEFC) whose role is to overcome market impediments and help accelerate Australia towards the transformation to a low carbon economy, minimise its ultimate cost and create positive adjustment for the economy, including through new forms of clean technology business, new jobs, development of new or expansion of existing businesses and

development of new technological know-how. However, the NZ version of such a fund would need to be scaled to a NZ project size.

- The CEFC places priority on its investments generating economic, social and environmental benefits, including building capacity and capability within the renewable and low carbon energy sector, demonstrating applications and financing for new technologies, development of new or existing businesses and the development of new technologies and know-how.
- CEFC investments to date - even at this initial phase - are demonstrating the potential to expand Australia's manufacturing capability and create new industry and employment opportunities across the country, particularly in regional areas.
- The CEFC's portfolio of contracted investments is expected to earn an average return of approximately 6.1 percent (as reported in their 2014-15 Annual Report). While New Zealand's lower population density may not produce such attractive returns, their participation in the market provides liquidity to ensure efficient pricing. CEFC's lower cost of funds, flexible structuring and capacity to match the term of the financing to the life of the assets has allowed them to de-risk transactions so that private financiers become involved.

6. Assistance to industrial and agricultural organic waste producers to reduce methane emissions

- EECA and the Bioenergy Association to work with other industrial associations to establish programmes for reducing methane emissions from industrial and agricultural organic residues.
- EECA and the Bioenergy Association develop the following Technical Guides:
  - Methods and evaluation of biogas technology options for methane collection and processing at industrial waste water treatment facilities.
  - Methods and evaluation of biogas technology options for processing agricultural residues so as to reduce methane emissions
  - Replace Code of Practice NZS 5228.1:1987, Code of practice for the production and use of biogas, farm scale operation - Production of biogas,
  - NZS 5228.2:1987, Code of practice for the production and use of biogas, farm scale operation - Uses of biogas.
  - Guide to using biogas as a vehicle fuel