Bioenergy Association of New Zealand (BANZ)

Biogas Strategy

2010 to 2040

BANZ Biogas Interest Group

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Acknowledgement

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1. Summary

The New Zealand Biogas Strategy was developed by the Biogas Committee of BANZ and is a 30-year outline of a potential sector development in this country. The purpose of this document is to assist the New Zealand biogas industry co-ordinate its aspirations and actions. It informs the government and energy sectors about the possible role that biogas can play in the future energy mix of New Zealand. It is a working document intended to be regularly reviewed and updated in the future.

30 PJ biogas energy per year by 2040 from anaerobic digestion is considered a reasonable target that takes into account market developments, the potential energy mix, security aspects, production capabilities and projected agricultural trends, and was based on the following grounds:

- Biogas is a high-quality, versatile form of bio-energy that will help secure the future energy demand to meet political, social, environmental and cultural needs of the nation.
- Declining domestic natural gas reserves and increasing world oil prices are driving the quest for alternative fuels and demand renewable alternatives and supportive market regulations.
- Environmental pressure and the increasing cost of fossil fuel imports are likely to change the economics and dynamics of the current exchange of NZ agricultural products for foreign fossil fuel energy. These drivers will create opportunities for less energy intensive and more environmentally friendly land use alternatives and the production of reliable, environmentally sound, domestic renewable fuels.
- From its experience with landfill and sewage gas, New Zealand has developed considerable expertise in the production and utilisation of biogas and has become a leading nation with regard to biogas production per population and GDP.
- More intensive agricultural production is likely to demand the increased use of anaerobic digestion as a means of improved environmental management. In the dairy and meat industries, biogas will be a by-product available at marginal cost.
- Biogas can be upgraded to natural gas quality and can substitute for reticulated natural gas used by residential, commercial and vehicle fuelling sectors.
- The target of 30 PJ of biogas energy is based on anaerobic digestion and does not include synthetic natural gas made from wood or other renewable, organic feedstock. Thermal biogas technologies are not yet included in this strategy as they have not been proven sufficiently.
- Biogas production from energy crops as demonstrated in Europe has the largest but untested potential. Biogas energy yields from crops are higher per unit land area than for any other practical 'energy crop to bio-fuel' processing pathway currently available, while parasitic energy consumption of the process is minimal. Therefore energy crop derived biogas is likely to be a development priority for New Zealand. Climatic factors for high yield are more favourable here than in Europe where it **is** tested.

- Biogas technologies have reached a level of maturity and automation that can be customised for New Zealand farmers, communities, co-operatives or industrial plant.

Mangere Wastewater Treatment Plant

2. Energy Mix

A 30 PJ per annum biogas target for New Zealand is considered realistic as part of a 200 PJ total bio-energy goal and lines up with current overseas experience in countries with similar agricultural land area. Also, this focus is appropriate for an economy that is based on the export of biological products. In the past, New Zealand's production advantages relied on the availability of low cost energy in the form of fossil fuels. To prepare for a future, where fossil fuels will be more expensive and less easily available, it is therefore necessary to broaden the NZ energy mix away from fossil fuels, for enhanced energy security and achieving environmental goals. Sustainable energy practices are therefore not only desirable but also necessary.

As NZ and other OECD countries will be in increasing competition for fossil fuel resources with emerging economies in Asia, the energy mix will have to change from predominantly being based on non-renewable energy in the form of coal, oil and gas to being predominantly based on renewable energy in form of hydro, geothermal, wind, solar, marine and bio-energy, during the next 30 years.

BANZ welcomes the 90% renewable energy target for electricity generation and the inclusion of energy efficiency as a parallel strategy to renewable energy generation. The proposed energy efficiency target will have the effect that the per capita demand of energy will reduce at about the rate of population growth. This would keep the overall energy demand steady and would allow future benchmarks to be based on today's energy demand.

The 30 PJ per annum biogas target by 2040 for anaerobic digestion (AD) is in the view of the authors a probable scenario, considering the urgency for alternative gas supplies in this country and the technological progress made internationally. The supply is likely to continue to be based on waste streams as feedstock during the first decade, with the use of residuals, by-products and dedicated energy crops envisaged to increase in the following two decades.

Since there are currently no AD plants using energy crops in New Zealand, the production target of 15 PJ from crops is projected on the basis of overseas experience, where a supportive policy environment has been in place for many years. In Germany for example, a country with an agricultural land area just above that of New Zealand, biogas from crops has exceeded biogas from landfills by a factor of four and has reached about 100 PJ per year. This amount would exceed the 80 PJ of non electricity generation natural gas demand in New Zealand.

A New Zealand target of 15 PJ per annum from energy crops in 30 years time is therefore rather conservative, even considering agricultural sector factors such as slowness to change production methods and the degree of financial speculation that often drives decisions. It is also based on a realistic estimate of the areas of suitable land available which excludes steeper slopes better used for trees than either biogas crops or grazing. New Zealand's very favourable climate and land resource are good reasons to be confident that overseas findings can be matched or exceeded here.

While our 2040 target of 15 PJ biogas energy from crops (30 PJ total) appears feasible, an alternative scenario is that by 2040 there will still be no urgency for transport fuel substitution and no policy encouragement to develop biogas for fuel. In this case the overall target would only be 15 PJ.

Most crops used as fodder for dairy and meat farming are suitable for biogas production, but targeted research will be able to identify even more productive biogas energy crops for each region of NZ, often adapted to suboptimal pasture sites. Crops such as sorghum and winter legumes are currently available but not widely used in our country. Biogas energy cropping could become a sensible agricultural production alternative for areas where traditional farming practices are challenged (e.g. catchments prone to nutrient leaching, bio-security hot spots with invasive pests etc. and irregular paddocks not conducive to annual cropping or fencing.

Unlike forestry biofuel systems, the feedstock base for biogas energy systems can be established within months, making it very well suited to react to crisis situations like an oil shock or unexpectedly rapid depletion of indigenous natural gas supplies. The production of large quantities of dedicated energy crops for anaerobic digestion can be supported by, and leverage off, the recent advancements made in the modernisation of on-farm silage and concentrated animal fodder production due to the extensive use of contractor services and / or cooperative equipment use.

Despite such solid foundations, the adoption of biogas energy cropping as a common agricultural practice will take time and leadership. BANZ will therefore lobby for the development of demonstration projects at an early stage. In the event of an energy crisis, New Zealand needs to be well prepared for, and experienced in, the efficient production of energy crops suitable for biogas production. A sensible starting point for such demonstration plants would be rural biogas plants digesting currently underutilized farm residuals with properties similar to energy crops. This could include cereal straw in Canterbury, maize straw in the Waikato, and orchard grass and pasture toppings in the Bay of Plenty.

Renewable fuel gas can also be produced with thermal technologies, such as pyrolysis, using wood or other organic substrates as feedstock. This technology was used during the Second World War as a substitute vehicle fuel and has been revived in the past ten years. The developed technologies are now able to produce a synthetic natural gas that is similar to natural gas and can be reticulated in existing pipeline networks. The technologies are promising, but still very expensive and not as simple and modular as anaerobic digestion. For this reason, synthetic natural gas (SNG) made from wood is not yet considered within the target for biogas. Also, SNG is typically made from wood as a feedstock, which is already accounted for in the NZ Bio-energy Strategy.

3. Some Facts about Biogas

Biogas is a combustible gas derived from renewable biomass that can be used similarly to non-renewable natural gas. The main and energetically most valuable component of both biogas and non-renewable natural gas is in fact the same molecule – methane. The most common method of biogas production is a process called anaerobic digestion, where microorganisms convert biomass to biogas in the absence of oxygen. In general all non-woody biomass feed stocks are suitable for the production of biogas via anaerobic digestion, this includes wastes from livestock, organic municipal waste, wastewater biomass, food processing wastes, farm residues such as straw and energy crops such as grasses, legumes and algae. Thermo-chemical processes (SNG production) are also able to achieve the conversion of biomass to biogas, also from woody feed stocks, but are not yet available and proven for field application.

Biogas made from anaerobic digestion mainly contains methane and carbon dioxide in a mix approximately ranging from 50/50 to 70/30, In New Zealand, most utilized biogas is produced in landfills (about 70%) and at wastewater treatment plants (about 25%). Only very few farms and industrial processing sites utilize biogas, and there is a great scope for future expansion. In the decades ahead much higher volumes of biogas are projected to be produced using farm residuals and energy crops, which can often be utilized together with agricultural wastes and food processing wastes in common digestion facilities. Anaerobic digestion is an efficient means of managing organic waste and improving environmental stability.

Biogas is the most versatile and flexible renewable energy resource, relating both to the diverse range of feedstocks and digester configurations and sizes that can be used, but even more so to the diversity of biogas uses. Around the world, and increasingly in NZ, biogas is used as boiler fuel, for electricity generation in modular engine-generators and following more intense purification as vehicle fuel and for natural gas grid injection, allowing the subsequent use in a whole raft of applications, from home heating and cooking to chemicals manufacture. This intelligent use of existing infrastructure also provides options for energy storage and enhances the flexibility of biogas energy systems even further. In New Zealand, most of the produced biogas is currently converted to electricity for local grid distribution, but due to the steady increase in fossil fuel prices, an increase is expected in the use of biogas as vehicle fuel in the future.

A further advantage of the biogas production chain is the much smaller parasitic energy consumption, compared to other biofuels. Energy intensive processing such as distillation (as e.g. with bio-ethanol production) is not required.

European experience has shown that biogas energy cropping can achieve supreme energy yields per ha of land, on good soils over 300 GJ/ha, which is up to 4 times higher than the yield achievable with other biofuel systems such as biodiesel (see Figure 1 below).

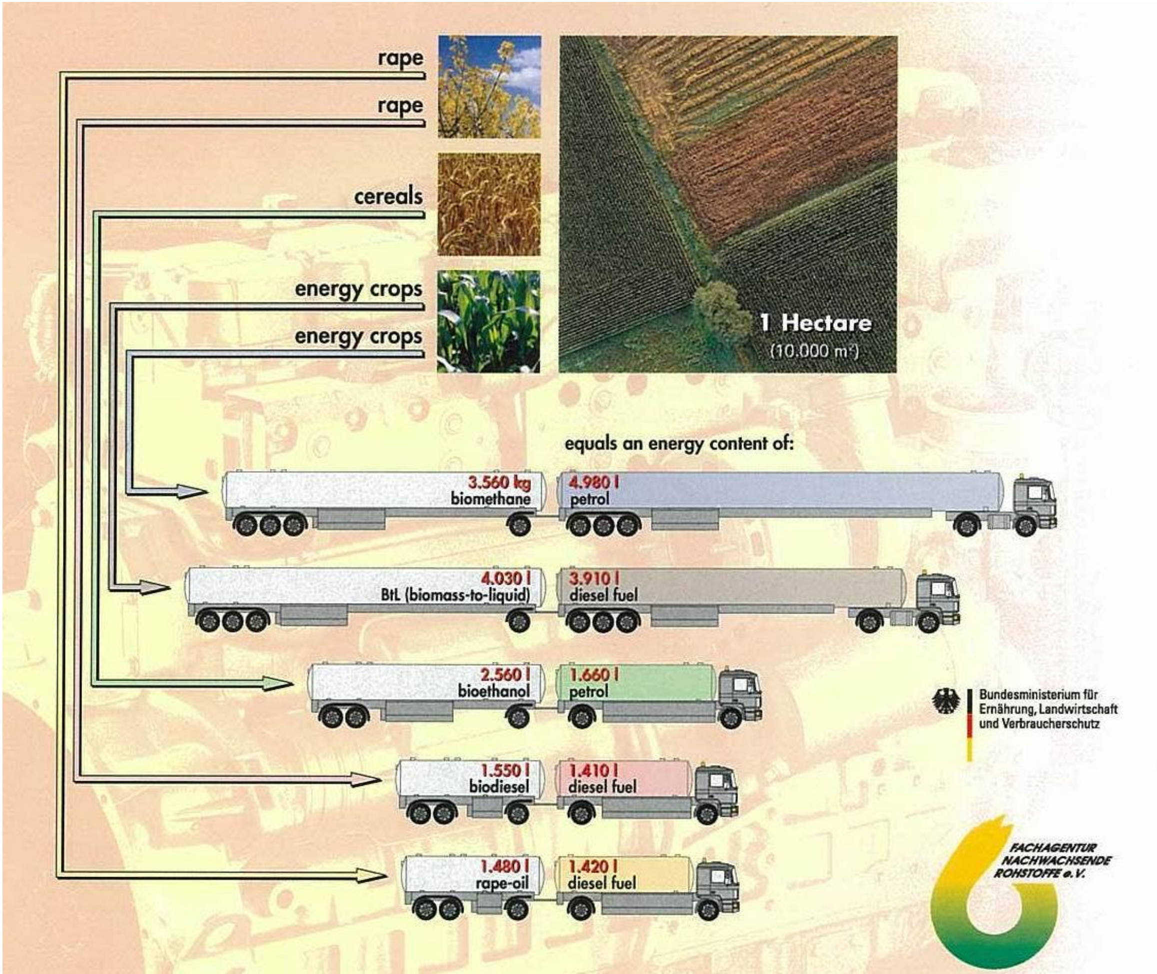

Figure 1. Energy yield from one hectare arable land for different biofuels compared as litres petrol equivalent.

Biogas is Greenhouse Gas (GHG) neutral because it is produced from plant material and combustion of biogas will add no more carbon dioxide to the atmosphere than the plant feed stock recently removed during growth. Often biogas technology can help to reduce GHG emissions, e.g. where biogas is recovered from wastewater treatment or farm waste treatment facilities, thereby eliminating fugitive methane emissions. The combustion of biogas causes less particulate emissions and other harmful air pollutants than with fossil fuels such as coal or petroleum product. Anaerobic digestion is an effective means to divert organic waste from landfills and enable nutrient recycling back to agriculture.

In many wastewater treatment plants AD is used to manage sludge. Such facilities can produce additional biogas if modified to receive agro-industrial or green waste, as demonstrated at the wastewater treatment plants in Christchurch and Palmerston North. The digestate by-product from rural anaerobic digestion can be directly used as valuable, organic fertiliser.

4. Biogas Production and Utilisation

Biogas can be produced from nearly any organic feedstock such as liquid / solid waste streams, energy crops, or algae. Currently, most of the biogas in New Zealand (4.5 PJ) is produced by anaerobic digestion in landfills and wastewater treatment plants, and generally used for electricity generation. Increasing interest in the farming sector indicates that there is significant potential to generate biogas from animal and farm waste while minimizing emissions to air and land (reducing pollution potential). The pig industry in particular has become a leading adopter of this technology in recent years.

Considering its geographical remoteness, small market size and difficulties in attracting new technologies, New Zealand does well with regard to use of renewable energy. In 2009, nearly 50 PJ of biomass was utilised for heat and electricity generation. Of this, 4.0 PJ came from biogas, ranking slightly behind wind energy, which produced 5.3 PJ during that year. On a use of biogas per capita basis, New Zealand compared favourably with the European Union only closely behind Germany and the UK with about 1 GJ per person or 3 GJ per household (see Figure 2).

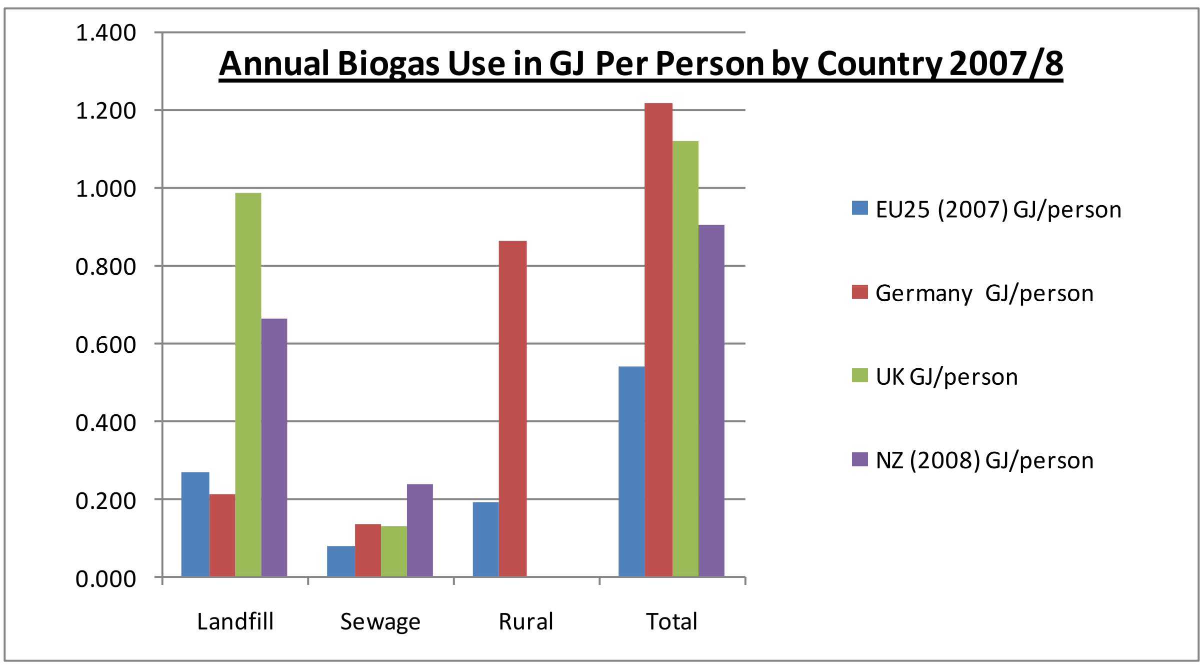

Figure 2. Relative per capita biogas utilisation in New Zealand and Europe, by gas source.

To put this into perspective, the residential consumption of natural gas in New Zealand was only 5.5 PJ in 2009, barely above the volume of biogas production. This shows that biogas produced from our waste provides a significant contribution to meeting community energy demand.

In most cases in New Zealand and overseas, biogas is utilised for the generation of electricity. The technology is well established with a wide range of gas engines are available in New Zealand.

A key development goal for the New Zealand biogas industry will be the upgrading of biogas to a specification suitable for piped reticulation. As a natural gas substitute, biogas could be used in all existing gas markets such as for co-generation of heat and power, in residential, commercial and industrial applications, as a renewable transport fuel in the form of compressed biomethane, aka compressed biogas(CBG), and as a feedstock for chemicals (including liquid fuels). CBG could also be stored together with natural gas in common storage facilities.

Sweden is making a major move to using upgraded biogas (biomethane) as a substitute for high value liquid vehicle fuels. In 2010 biogas supplied 2% of Sweden's road fuel needs. New Zealand, which still can leverage off our 1980s experience with CNG (when 10% of the vehicle fleet were using gaseous fuel on the North Island), could swiftly follows Sweden's example. Indeed several theoretical and practical investigations into the use of biogas as transport fuel are underway in New Zealand at present, which are supported by highly specialized and world leading manufacturers of biogas upgrading equipment, gas compressors and gas vehicles/components.

Another innovative example of advanced biogas use can be found in Christchurch. The City Council can pride itself of having developed the most integrated community scheme for biogas in New Zealand (see Figures 3 and 4).

Trigeneration from Landfill Gas in Christchurch

1. Landfill gas extraction and treatment with landfill gas (LFG) fired absorption chillers;
2. Piping of the LFG through directionally drilled gas pipelines to the WWTP;
3. Utilisation of the LFG en route at the QEII Aquatic Centre;
4. Upgrading of the biogas facility at the WWTP with thermophilic digesters for increased biogas production;
5. Further treating the clarified water in demonstration high rate algae ponds;
6. Using the algae for biodiesel production;
7. Piping the combined LFG and biogas to Council-owned facilities in the city centre;
8. Using the energy in tri-generation plants (power, heat and cooling) for Council-owned buildings;
9. Drying the biosolids with heat from LFG or renewable wood supplies;
10. Using the dried biosolids as a soil conditioner for restoration of coal mines.

Figure 3. Features of the landfill gas project in Christchurch

Figure 4. Artist's impression of Christchurch trigeneration plant building

This kind of innovation could be mirrored in a number of cities across New Zealand.

5. Economic Benefits

New Zealand's indigenous conventional natural gas supply is depleting. Some sectors, such as electricity generation may be able to switch some of the current gas demands to other fuels such as coal or geothermal. For many other natural gas uses, such as the majority of the entrenched industrial and commercial demand, higher cost replacements will have to be developed. In the absence of substantial conventional gas finds, these may well be unconventional fossil gas resources such as coal bed methane, tight gas or shale gas. These new supplies will be several times more expensive than the current conventional gas supplies, and may well reach price levels where biogas production will be competitive in its own right in the not too distant future (even if carbon charges for natural gas were not taken into account).

Regarding biogas transport fuel, sustained increases in the price of oil, or reduced physical availability of petroleum products, may well spur the development of regional demand. At a conservatively estimated net oil price increase of 5% per year the oil price will have quadrupled within 30 years. It can therefore be assumed that well before 2040 biogas will have become an economic alternative for several applications. Refer to Section 2 on Energy Mix for additional related discussion.

An economic analysis of biogas is more challenging than some energy technologies. Production cost projections are complicated by the wide range of set-up sizes, feedstocks digested, energy products provided and co-benefits realized with biogas technology. Compared, for example, with wind energy, where knowledge of equipment cost and wind speeds can provide rather accurate cost estimates, the economics of biogas technology are much more location dependent and multi-layered.

In the waste industry for example, mandates to capture and burn landfill gas provide primary biogas energy at zero cost. The cost of derivatives, such as electricity or biogas transport fuel, largely reflect modest equipment costs, which makes utilisation of this biogas resource potential a profitable undertaking in most situations today. Similar regulation could unlock equally low cost biogas opportunities in the wastewater treatment and farm waste area. In the absence of such regulations increasing energy prices over the next decade will be a driver for utilizing increasing volumes of waste derived biogas, albeit at a slower pace. Biogas systems based on farm residuals and energy crops are hardly economic today, and will remain that way if the produced biogas is intended to be used as boiler fuel or for electricity generation.

The use of waste and rural biogas as a transport fuel or similar high value uses, offers a value proposition which, in combination with steadily increasing petroleum prices, will make many schemes economic in the medium term. However, one prerequisite in this regard is relatively high but stable fossil fuel prices, as price volatility will lead to investment uncertainty and delayed uptake of the technology despite promising fundamental economics.

Relying on pure “push economics” for establishing a vital biogas sector in NZ, does however contain the risk of falling victim to the problem of the receding horizon – that is biogas energy systems always remaining marginally un-economic due to a lack of skilled labour and experience, risk premiums for investment capital, material and equipment cost inflation (triggered by higher energy costs) etc. It is therefore most important to establish working examples of the technology as soon as possible in order to minimize risk premiums and skill / knowledge gaps for future projects.

BANZ will promote the many associated benefits to government and the respective markets, which do justify early intervention, and include:

- reduced dependency on imported, fossil fuels;
- improved balance of payment – reduced current account deficit;
- lower national GHG emissions resulting from displacement of fossil fuels and reduction in fugitive methane emission from waste treatment;
- New Zealand’s green image boosted from burning a clean, locally grown fuel; this will give a concrete advantage to export products by reducing their environmental footprint;
- local environmental benefits from reduced pollution and improved soil fertility;
- industry development providing employment and economic growth in rural regions;

- low risk from using a well-proven technologies with standard equipment, e.g. IC engines, boilers etc; and
- flexibility with regard to feedstock, use of production equipment and mode of utilisation.

This chapter on economic benefits has demonstrated the potential importance of developing a New Zealand biogas energy sector linked to those sectors involved in environmentally sound wastestream management and sustainable primary production. It is also evident that there is a significant gap in the New Zealand economic analysis, including macroeconomics. This effort is strongly recommended despite some of the above-mentioned challenges.

6. Implementation

BANZ will promote research and development of technologies that support the growth of the biogas industry and suit New Zealand conditions. The focus will be on the following:

Biogas Production

- landfill gas extraction,
- wastewater treatment,
- solid organic waste treatment,
- farm wastes,
- food processing wastes,
- energy crops
- advanced AD nutrient recycling and re-use.

Biogas Utilisation

- co-generation and advanced use of waste heat
- biogas on-call generation for network stabilisation
- biogas upgrading, storage, transmission and distribution in existing pipeline networks,
- biogas as a vehicle fuel.

Industry development targets are not set in concrete and need to accommodate international and local market developments. However, they provide strategic direction to affiliated industries and will be revised as new market trends evolve. BANZ will monitor the development and facilitate communication between government and the industry on matters of market regulation.

The anaerobic production of biogas has the advantage of producing high quality fuel gas, which can be utilised with conventional equipment. Also, it converts wastes into an environmentally friendly fertiliser. This AD technology is well advanced and proven. By 2040 a number of arable and pastoral sector farms will need to be involved in supplying AD plants with non-woody crops, crop residues and manure, as well as the use and reuse of increasing volumes of digestate nutrients. More marginal land will be profitably converted from grazing to growing adapted energy crops such as maize, sorghum (in northern NZ) and perennial crops like lucerne or new crops that are being researched.

SNG can be produced using woody biomass from purpose grown energy forests and forest residues (targets for SNG are not yet formulated). The technology has already been demonstrated, but not commercialised. It would make productive and sustainable use of steeper marginal land.

Biogas production will be achieved with cropping rotation systems that are already being tested to ensure sustainability. The opportunity to convert marginal land into productive energy paddocks and reuse nutrients from the digester, rather than purchase them, will have particular (but not exclusive) relevance to Maori landholders. The next step is testing of AD plants which are supplied with crop biomass in New Zealand. BANZ sees its role in the promotion, selection and evaluation of such trials. This will be an ongoing learning process, which will in return influence the proposed targets.

In summary, BANZ will have a continuous role in the development of the New Zealand biogas market and will be a responsive, well regarded and accessible forum for government and private industry.

7. Biogas Strategy and Vision

BANZ's strategic goal is that biogas generation opportunities are identified, encouraged and facilitated where practical. Biogas shall be recognised as a major, sustainable source of electricity, heat, transport fuel and a sensible alternative to, and future replacement for, natural gas. The strategy is to further the development of an industry that provides an alternative energy resource and a waste management solution in an efficient, safe and socially and environmentally acceptable manner.

The following table sets out the key biogas resources in New Zealand with an indication of the total potential of each, the drivers for their use and a vision/target for generation and use by 2040.

Resource	Supply of raw resource left	Effort to utilise	Comment	Drivers	Vision
Landfill	Moderate	Low	Significant potential as gas capture is now required in landfill design.	environmental drivers; added value; consolidation of many small landfills into bigger, better managed ones, innovation; gas capture regulation	100% of collection opportunities realized. Employed systems aiming for > 85% total recovery
Waste water	Low to moderate	Low	Potential for significant activity	environmental drivers Increasing energy cost for advanced WW treatment ; added value; innovation	Mandate to collect biogas above specified minimum size plant. Integration of anaerobic wastewater treatment steps incorporating biogas recovery as the method of choice for future capacity additions at established WWTP
Solid Waste	Low to moderate	Moderate	Potential for significant activity	environmental drivers environmental drivers; added value; innovation, nutrient recycling	Anaerobic treatment with biogas recovery established as a standard addition / alternative to composting
Rural Waste	Moderate	Low to moderate		Additional value; environmental drivers, such as agricultural GHG emission reductions	Build on progress made by some farming industry bodies (eg the Pork Industry Board) and also initiatives such as the Clean Streams Accord. Biogas recovery from farm wastes well established as a practical means for agricultural GHG emission reduction and enhancement for rural energy security
Food Processing Waste	Low to moderate	Moderate	Limited potential;	Environmental regulations, nutrient recycling	All industrial, organic waste to be treated and not landfilled Rural AD clusters with nutrient recycling established around most agro-industrial processing industries producing organic waste
Energy Crops	Very high	Very large	significant potential	Price of fossil fuels; Means of GHG offset to reduce footprint of export products; Energy security	Significant contribution by 2040; New crops help protect sensitive farming environments; Biogas substitution for fossil fuels

Figure 5. Resources, drivers and vision for biogas production in New Zealand by 2040

In line with the three phases identified in the Draft New Zealand Bioenergy Strategy, the Biogas Strategy proposes the following Figure 6 phases and targets for production and use:

PJ/year	**2010**	**2010 – 2015 Establishment Phase**	**2015 – 2020 Development Phase**	**2020 – 2040 and beyond Expansion Phase**
Landfill	3.5	5	5	7
Water treatment facility	0.7	1	1.5	1.5
Solid waste treatment facility	0	0.2	1.0	1.5
Food processing	<0.1	0.4	1.0	1.5
Rural waste and residues	<0.1	0.5	1.5	3.5
Energy Crops	0	0.4	5	15
Total	**4.5**	**7.5**	**15**	**30**

Figure 6. Targets for Production and Use during the 3 phases of sector development. The table is based on anaerobic digestion only and does not include synthetic natural gas (SNG).

These outline notes provide the basis for the energy production targets in each row in Figure 6, envisioned by 2040 in the Biogas Strategy:

a) Landfill Gas:

Typical trends in landfills include increased recycling of waste, closure of small landfills and operation of larger regional landfills and improved capture of landfill gas through better lining and extraction techniques. While it is now mandatory that landfills be designed to capture landfill gas it is currently estimated that only about 50% of the gas is captured for energy production, although new designs can capture up to 90% of produced landfill gas. In New Zealand currently about 3.3 million tonnes of municipal waste goes to landfill. Current generation levels are around 260 million m^3per annum of landfill gas.

As all new landfills are required to capture landfill gas, the potential for future use is significant. Future activities in this area will be on treatment technologies to reduce treatments costs and the development of even more advanced capture technology. While innovation such as demonstrated in the Christchurch Tri-generation Plant is to be encouraged, many sites where capture and use is an option either have no economic gas demand of their own or are too distant from a suitable energy demand . It is therefore important to develop sensible mechanisms that would allow for better energy export from landfill sites, such as feed-in tariffs, and work to establish collaborative, regional models for better landfill gas use. The obvious drivers here are utilization of a free energy source, innovation, minimization of leaking gas risk, and effective management of the landfill site.

b) Municipal organic solid and Wastewater Treatment Facilities:

Wastewater treatment plants are relatively mature in New Zealand with regard to the chosen treatment processes and may not grow substantially beyond the growth rate of population. For wastewater a quite likely scenario is for increases to be driven by measures to reduce odour emissions even at smaller sites, and the increasing electricity demands (and costs) for advanced WWT systems will make biogas energy increasingly valuable for onsite generation. Municipal organic solid waste (and food processing) biogas targets are likely to be achieved if the related targets in the government strategy on waste minimization are to be met. Many established composting sites could adopt anaerobic digestion for a proportion of their current input materials. Long term development of this sector is strongly dependent on the price and land application rules around recycled AD fertilizer nutrients.

It is estimated that New Zealand produces around 800,000 m^3/day of municipal wastewater that requires treatment (300 million m^3/annum). It is further estimated that around 50 % of treatment facilities currently produce biogas from wastewater treatment sludge digestion. Meat processing plants in New Zealand produce about 20 million m3/annum of processing wastewater. A very small proportion of that is currently used for biogas generation. About 0.6 PJ/annum of biogas could be generated with the captured solids from that wastewater. Dairy processing plants in New Zealand produce about 60 million m3/annum of processing wastewater. A very small proportion of that is currently used for biogas generation. About 1.1 PJ/annum of biogas could be generated with the captured solids from that wastewater. Activities may focus on identifying and enabling biogas production opportunities through knowledge sharing. The obvious drivers here are utilization of a free energy source, minimization of risk, effective management of the wastes and production of useable digestate as a nutrient resource.

Tirau biogas reactor for dairy wastewater

Wastewater treatment in Christchurch

c) Biogas from rural waste streams:

Growth is expected in this area with the chief drivers for better animal manure management being environmental. Development is strongly dependent on future regulatory requirements for advanced cow shed effluent management and water protection. Also rural GHG emission pricing can accelerate or decelerate development, as methane recovery from manure is one of very few practical steps for the dairy and pig industries to reduce GHG emissions. Co-digestion of crop residues could add considerable methane production. New Zealand could be extracting over 6 PJ per annum of biogas from rural organic wastes. Current levels are close to zero. Activities may focus on identifying and enabling generation opportunities, knowledge sharing, and accumulating rural and industrial wastes to deliver economically viable volumes for generation.

Other drivers are utilisation of a free energy source, minimization of pollution risk, effective management of the wastes, and production of digestate as a nutrient resource. It is estimated that annually rural New Zealand produces several million tDM of livestock manures per year, but less than 600,000 tDM is contained in feeding or milking areas where it could be utilized to produce biogas. Further, crop wastes are estimated to total 500,000 tonnes per annum of material that could yield much more biogas per tonne than manure. Co-digestion of manure with crop residues would improve the economics of digester investment.

An AD digester in Canterbury uses dairy waste (courtesy Natural Systems Ltd)

d) Food Process Waste:

Although biogas production from food processing waste alone has been regarded as uneconomic where the use as animal feed is an option, there are many wastes and by-products that can be digested. Food processing wastes are often seasonal and can make a valuable contribution to the feedstock supply of regional digester facilities, in particular where several seasonal supplies can be combined. Bio-security concerns and management control over the waste can be further drivers for considering biogas production for some food processing wastes. New Zealand companies have been design/building such AD plants for a number of years overseas and the first was recently built in New Zealand.

e) Energy crops:

In the long-term, this biogas source has the greatest potential for the gas production. It will be driven by the availability of domestic natural gas, international prices for fossil fuels, the economic cost of greenhouse gas emissions and government incentives addressing national energy security, rural development and land management. Biogas cropping in good farming areas such as the Waikato could yield over 300 GJ/ha/annum and only moderately less in some marginal sites with the right crops and adequate rainfall. It could be a valuable tool to partially mitigate problems associated with current farming practices such as nutrient leaching and run-off, water abstraction conflicts and odour and GHG emissions.

Sorghum and maize crops for energy production

8. BANZ Action Plan: realizing the biogas potential in NZ

The potential for increased biogas production in New Zealand will be coupled with the national waste minimisation strategy and community aspirations to utilise waste for beneficial outputs.

Biogas production from landfills and sewage treatment plants is likely to continue for the next decades as municipal facilities are upgraded or replaced. A key focus in the coming years will be the improvement of the biogas conversion and capture in rural and municipal facilities. Smaller communities are likely to combine their waste treatment systems to improve the scale and economics of the process. Standardised generator sizes will be between 500 kW and 1 MW, suited for modular container units as illustrated by a landfill gas application in Wellington. Co-digestion of industrial organic waste together with farm waste and municipal waste is a means of better utilising the digester volumes, leading to higher concentrations of organic solids and greater yields per installed volume.

Following European examples, the New Zealand biogas industry may also look at upgrading biogas to a quality that would make it usable as a transport fuel in particular applications and ultimately as a substitute for local reticulated natural gas. New Zealand companies have been exporting biogas treatment plants to Europe and Japan and are also demonstrating modern aspects of this technology for the production of compressed biogas as a vehicle fuel in New Zealand.

About 90% of New Zealand's primary sector production is destined for export and a large part of the earnings (about equal to dairy exports) are required to pay for our country's fuel imports. Agriculture is also a large source of greenhouse gas emissions. Furthermore, it has large waste and by-product streams, such as farm effluent, crop wastes, straw, whey, inedible slaughterhouse wastes and rejected fruit and produce. Part of the current waste streams are not utilised and a large part is even an environmental problem or nuisance. Anaerobic digestion will have an increasing role in the mitigation of these environmental impacts. Further in the future, the gasification of wood will provide a second conversion technology that can also be used for woody and non-woody bioresources as a potential alternative to using them via anaerobic digestion.

There are some existing barriers to commercialisation, mainly related to the need to invest capital to achieve economies of scale in the AD industry. There are thousands of small-scale projects available to be developed (say <100kW, dairy farms in particular) but these projects are uneconomic with prevailing substitute energy prices. This could be overcome with a mechanism to better reward the project owner (e.g. Feed-in tariff, recognition of reduced GHG emissions and better effluent management). Another avenue is for the industry to develop simpler less capital intensive set-ups to help unlock this potential. A third way scale issues could also be addressed is by cooperation and co-digestion. Multiple farms could invest in a larger biogas plant owned on a co-op basis, digesting manure, farm residues and energy crops from their district.

The following, phased Action Plan provides a degree of direction to the existing and future New Zealand biogas industry, including those organisations that are and that are not members of BANZ.

8.1 Establishment Phase (2010 to 2015)

During this phase BANZ will identify niche opportunities, to consider innovative approaches and keep abreast of international developments.

a) **Prioritising:** Immediate focus on biogas input to the BANZ activities funded by NZTE to develop a NZ Bioenergy Strategy Implementation Plan, including a Gaps Analysis; activities for this include: discuss the above phase targets table for each biogas category as part of identifying gaps, based on the BANZ Reference Scenario. Make a case for including an Urgent Response Scenario to be included for preliminary economic analysis in the Implementation Plan.

b) **Economic Analysis**: Evaluate local and international experience and compare the project economics of potential biogas applications to explain costs and benefits.
c) **Market Analysis:** Establish clear records of generating and use situations at landfills and water and solid waste treatment facilities across New Zealand noting existing generation, the economic but not yet generating sites and the not yet economic sites. Focus initially on the low hanging fruit (i.e., those sites that are currently economic but not used) with incentives to Councils to pursue innovation (as in the case of Christchurch City Council) and utilize biogas energy. Keep statistics on market developments.
d) **Knowledge Sharing:** Inform and share knowledge to Council and other operators of landfills and solid and liquid waste treatment plants to ensure technology transfer and skills development.
e) **Co-ordination of Studies:** Development of Case Studies with a step by step guide to biogas collection and utilization across a range of site sizes and advice on how to make sites economic covering landfills, solid and liquid wastes.
f) **Funding of Projects**: Encourage collaborative work between the various industry parties to ensure funding of demonstration projects.
g) **Regulations:** Engage with regulators (Regional Councils) on the opportunities and benefits of anaerobic digestion in farm waste management. Further the establishment of several region and sector specific reference projects.
h) **Industry Leadership**: to facilitate uptake and skills transfer including workshops and training. Collaborative approaches are to be encouraged between the Bioenergy Association, Councils, Engineering Associations, Farm and Agriculture focused Associations, and Food Industry bodies.
i) **Government Engagement** regarding the development of economic and regulatory incentives and frameworks impacting on biogas technology utilization:
    - From an energy point of view
        - Future Transport bio-fuels strategy (e.g. tax break)
        - Transport fuel security planning
        - 90% renewable electricity target
        - FIT legislation
        - Clean heat codes and regulation
        - ETS – energy emissions
    - From an environmental point of view
        - Waste minimisation bill
        - National nutrient security planning
        - Biogas capture mandates (landfill / WWTP)
        - Farm waste management codes
        - Regional council guidelines i.e. rural industry odour management
        - ETS – fugitive methane emissions
j) **Research and Development** programmes on improving efficiencies, techniques and feedstocks to maximize generation potential.
k) **Building on progress** made by some farming industry bodies in the promotion of anaerobic digestion, while addressing environmental issues.
l) **Niche Opportunities**: identify opportunities for the demonstration of innovative technologies and land use, such as biogas from purpose-grown energy crops.

8.2 Development Phase (2015 – 2020)

During this phase BANZ will build on progress made by some farming industry bodies to generate power and or heat from biogas, while addressing environmental issues.

a) **Demonstration** of full scale advanced biogas utilisation systems e.g. large fleet biogas transport fuel use, biogas injection into NG grid, on-call biogas electricity generation in collaboration with industry and councils.
b) **Development of tools and guides** that focus on techniques and designs to maximize yield and recovery at landfills, and water and solid waste treatment facilities.
c) **Roll-out** of biogas recovery at smaller municipal WWTP sites potentially aided by new legislation akin to landfill gas capture mandate.
d) **Integrated biogas systems:** Implementation of demonstration sites that manage waste and provide electricity, heat and transport fuel for local businesses and people while making local farming more nutrient self-sufficient and providing local employment.
e) **Trans-regional biogas trades:** Demonstration of initial cases using the existing North Island NG network for biogas conveyance and storage.
f) **Good agricultural practice:** Mainstreaming of biogas recovery from farm wastes by incorporation of AD (e.g. clean streams accord extension).
g) **Market Analysis:** Establish rural AD feedstock volumes and economic feasibility of supply logistics and AD plant construction in several regions of New Zealand. Identify opportunities, with a focus on the low hanging fruit. If not done during Phase 1, include analysis of an Urgent Response Scenario, whereby larger scale biogas production from energy crops is likely to be found economically feasible. The viable production scale in such a scenario could considerably exceed the 2040 target of 30 PJ.
h) **Industry leadership:** facilitate uptake and skills transfer including workshops and training. Collaborative approaches are to be encouraged between the Bioenergy Association, Councils, Engineering Associations, Farm and Agriculture focused Associations, and Food Industry bodies. The rural and food sectors and AD engineers could, on the basis of an encouraging market analysis, have plans in place for rapid implementation.
i) **Research and development programmes**: improving efficiencies, techniques and feedstocks to maximize generation potential and improve economic potential.

8.3 Expansion Phase (2020 – 2040 and beyond)

a) **Support mechanisms and regulation:** Mainstreaming of demonstration projects mentioned in Phase 2 supported through ongoing knowledge transfer and sensible, progressively developed regulations.
b) **Natural Gas network for biogas**: Substantial use of conveyance and storage of biogas within the NG grid.
c) **Substitution of fossil fuels** in traditional petrochemical processing industries (e.g. methanol manufacture) by using the NG network for collection of biogas volumes from many small producers, overcoming the current scale mismatch.
d) **Rural sector scale-up of feedstock production:** Cropping rotations adopted that identify residues from food crops and biomass crops to be grown to meet supply contracts with AD plant operators.

9. Case Studies

One way to indicate the New Zealand potential for the uptake of biogas energy technology by local authorities, companies and the farm sector is to examine the record in New Zealand and other countries.

9.1 Case Study No. 1

A 2008 research paper examined the feasibility of a 0.5 MW farm biogas plant in Germany using crops and some manure as feedstocks. It was shown to be profitable for generating electricity in the German context (with a feed-in tariff electricity price to the farmer).

In 2008 results of the technical analysis in the German study were applied to New Zealand conditions in a report prepared for the maize grower group within the Foundation for Arable Research. With New Zealand prices for electricity and maize silage (the main German feedstock) it was not profitable to use the biogas to generate electricity to sell into the grid, but more favourable if there was a local demand for the power. Since the cost of transport fuel is higher than heating and power energy then biogas as a substitute for diesel fuel would already be close to profitable, depending on the prices of diesel and maize silage. Use of feedstocks that do not have as high a value for dairy forage as maize silage would improve the economic feasibility.

Citations for Case Study No. 1

Renquist, R and J H Thiele 2008. Potential to produce biogas from maize silage for stationary power and fuel. Report No. 2167 by Crop & Food Research for Foundation for Arable Research, Lincoln (report owned by FAR).

Wiese, J and O Kujawski 2008. Operational results of an agricultural biogas plant equipped with modern instrumentation and automation. Water Science & Technology 57(6): 803-808. (this paper is kept on the BANZ Biogas web page; the link to the paper is:

http://www.biogas.org.nz/Publications/Resources/operational-results-JWiese-OKujawski.pdf

9.2 Case study No. 2

This is a 2009 report from the IEA Task 37 group researching the topic Energy from Biogas and Landfill Gas within the Bioenergy division of the International Energy Agency. It contains several assessments of biogas production from crops, with figures often aggregated for 15 nations.

Topics reported include how the use of energy crop digestion has developed (crops used in AD, technology for AD of crops and specific examples of energy crop AD alone or with co-digestion). It provides practical applications of energy crop digestion, long term biogas plant operational experience, biogas yield per hectare of crops and net energy yield per hectare of crops.

Citations for Case Study No. 2.

Braun, R, P Weiland and A Wellinger 2009. Biogas from energy crop digestion, 19pp. Task 37: Energy from Biogas and Landfill Gas, IEA Bioenergy.

http://www.biogas.org.nz/Publications/Resources/biogas-from-energy-crop-digestion.pdf

9.3 Case study No. 3

This is a 2010 report from the IEA Task 37 research group on the topic of utilization of digestate from biogas plants as biofertiliser within the Bioenergy division of the International Energy Agency. The information in this brochure is intended to inform prospective biogas/digestate producers as well as policy makers and regulators.

It aggregates a number of case studies from work in 15 EU countries, listing nutrient concentrations of selected manure sources, nutrients in feedstocks co-digested with manures, and a comparison of AD digestate to various manure types in terms of N utilisation in the fertilised crop, etc.

This report has chapters on storage of digestate and methods of field application. The beneficial environmental effects of using digestate rather than manures as a fertiliser includes reduction in odours, plant pathogens and weed seeds.

Citations for Case Study No. 3.

Lukehurst, CT, P Frost, T Al Seadi, 2010. Utilisation of digestate from biogas plants as biofertiliser, 21pp.

http://www.biogas.org.nz/Publications/Resources/utilisation-of-digestate-biogas-to-biofertiliser.pdf

Task 37: Energy from Biogas and Landfill Gas, IEA Bioenergy.
Renquist, R and S Heubeck, 2009. Nutrient value of AD digestate. Fact Sheet in BANZ biogas website.

http://www.biogas.org.nz/Publications/Resources/Biogas-Digestate-Factsheet_Renquist-Heubeck.pdf

9.4 Case study No. 4

This 2010 New Zealand project involved an innovative scheme by a Taranaki business to improve manure management and benefit the environment with a technology (AD) that produces electricity and heat in the process. The business is the pig farm of Steve Lepper. The farm was named winner in the Small-Medium Business category in the 2010 EECA Awards.

The system consists of a purpose-built effluent pond that can hold 7000 m^3 of waste, with a cover that stores the biogas. This gas is piped to a combined heat and power (CHP) unit which processes it to make electricity, and this electricity is then used to power the piggery. A 'heat recovery' system is also being installed which will use waste heat to heat water, some of which will replace electric heating for young pigs.

In its first month, the system produced 133m³ of gas per day, and daily electricity use in the piggery dropped by 28%. When fully commissioned, the system is expected to save the farm more than $65,000 a year in electricity costs.

The Lepper biogas project was supported by New Zealand Pork, which itself won a Commendation in the Innovation category for its work researching, and trialling biogas on pig farms. To date, it's helped set up three systems on North Island farms, with more in the pipeline.

As well as cutting the farm's running costs by providing ‘free' electricity, the system eliminates the issue of dealing with waste. There are no disposal costs; the smell (which can be a sore point for neighbours) is removed; and thanks to the anaerobic digestion that happens in the pond, the result at the end of the process is a nutrient-rich - and odour free - fertiliser for the adjacent family farm.

Citation for Case Study No. 4.

http://www.eeca.govt.nz/node/11302

Appendices

A 1 Glossary of Biogas Processes & Products

Biogas Terms and Definitions were sourced from “Specification for Whole Digestate, Separated Liquor and Separated Fibre Derived from the Anaerobic Digestion of Source-Segregated Biodegradable Materials”, PAS110:2010, published by British Standards Institute; and “Design of Municipal Wastewater Treatment Plants” Fifth Edition, Water Environment Federation, Manual of Practice No. 8, 2010)

Anaerobic Digestion (AD) Process of controlled decomposition of biodegradable materials under managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring anaerobic and facultative bacteria species, that convert the inputs to biogas and whole digestate.

Biogas The gas mixture produced by anaerobic decomposition of organic matter, comprising methane, carbon dioxide, hydrogen sulphide and trace gases. Also known as Landfill Gas, Sewage Gas or Digester Gas

Biomethane Methane which is produced by anaerobic digestion and separated from the biogas mixture.

Biosolids Solids that have been removed from wastewater (as sludges) and stabilised (e.g. digested or composted) to meet the criteria in the US Environmental Protection Agency’s 40CFR503 regulations and, therefore, can be beneficially reused on land.

Biowaste Waste of animal or plant origin which can be decomposed by micro-organisms, soil-borne organisms or enzymes.

Compressed Biogas (CBG) Biogas with the carbon dioxide, hydrogen sulphide and other contaminants removed, so that methane content is greater than approximately 99%, and then compressed into cylinders for use as a vehicle fuel.

Co-Digestion A process in which two or more organic feedstocks are digested in the same reactor. Normally refers to anaerobic digestion of wastewater solids together with, food wastes, fats / oils / greases (FOG), or other organic wastes. In a farming context it often refers to digestion of manures with crop material.

Digestate Refer to Whole Digestate

Digester Closed vessel system in which biodegradable materials decompose under anaerobic conditions.

Digester Gas Biogas produced from sludge in closed tanks normally at a wastewater treatment plant. See also Biogas.

Landfill Gas Biogas produced by the anaerobic decomposition of organic wastes in refuse landfills.

Separated Fibre Fibrous fraction of material derived from separating the coarse fibres from whole digestate. Note: At least 15% of its mass should be dry matter in order that the sample is suitable for laboratory tests as a 'solid' material.

Separated Liquor Liquid fraction of material remaining after separating coarse fibres from whole digestate. Note: It is normally separated using a fine screen or centrifuge to remove coarse fibres. Less than 15% of its mass should be dry matter in order that the sample is suitable for laboratory tests as a 'liquid' material.

Sewage Gas Refer to Biogas and Digester Gas

Soil Improver / Conditioner Material added to soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical or biological properties or activity. Digestate can be a soil conditioner when applied to land.

Source Segregated Material or biowastes of the types and sources sought, that are stored, collected and not subsequently combined with any non-biodegradable wastes, or any potentially polluting or toxic materials or products, during treatment or storage (whether storage is before or after treatment). Note: Source segregated materials can include collection of a mixture of biowaste / biodegradable material types, from more than one source. Such materials do not include sewage sludges and their derivatives, because source control is absent.

Whole Digestate Material resulting from a digestion process, and that has not undergone a post-digestion separation step to derive separated liquor and separated fibre. Because the digestate is high in organic matter it helps improve the soils structure thus enhancing the water retaining and air exchange qualities of soils. The digestate also provides nutrients to the soil and thus also acts as a natural fertiliser. The concentrations of the nutrient phosphorus are of particular interest in this regard as global phosphorus production is dominated by a limited number of (un-friendly) countries, and increasing competition from emerging Asian economies will make it difficult for phosphorus importers like New Zealand to secure adequate supplies in the future.

A 2 Biogas Uses

There are several established key uses for biogas:

- **Electricity Generation** – while a technical possibility, the volatile spot market prices for electricity in NZ make electricity generation a very risky undertaking and often economically unattractive. In the absence of sensible mechanisms, such as a feed-in tariff system, biogas electricity generation for export will remain a use of last resort, often not more attractive than flaring, for landfill operations in particular. On-site use of biogas-derived electricity however is in most cases a financially very attractive proposition. Biogas electricity generation is therefore very attractive for wastewater treatment plants.

- **Heat Generation** – Heat generation and in some specific cases combined heat and power are likely to be straightforward and economic uses for biogas, if biogas production can be located close to a consistent (and high) heat demand.

- **Transport** – Use in transport is the highest value use for biogas. Currently this application is limited to local niches such as bus or taxi fleets, council vehicles, refuse trucks and fixed route trucks. Thorough purification of the biogas prior to use is required, however given sufficient scale, investment costs for biogas upgrading and compression won't be much more than the investments required for electricity generation equipment.

- **Natural gas pipeline injection** – This technology pathway enables "mainstreaming" of biogas. Once in the pipeline purified biogas can be use for all applications that natural gas is currently used for. The purification required is the same as required for the transport fuel pathway. Since New Zealand's natural gas network is not very widely developed (e.g. missing completely in the South Island) this option has natural limitations. Biogas injection into the natural gas pipeline network is financially more attractive and less risky than electricity generation at spot market conditions, but less attractive than onsite CHP or the use as transport fuel.

As noted in earlier sections, the production of biogas as a means of waste processing and waste management and therefore its environmental (waste and climate change mitigation) advantages are clear. Further, the digestate by-product in both solid and liquid form provides a valuable fertilizer.

A 3 Biogas Drivers

The Drivers for use of biogas are environmental and economic. In particular the following are noted:

- **Energy Security** – like in many countries around the world, indigenous natural gas production in New Zealand is declining and there is uncertainty about the reserves of new fields. Biogas is potentially the only sustainable alternative to natural gas since LNG is neither affordable, justifiable from a (energy) security point of view, greenhouse gas neutral nor renewable as required by energy policy on power generation. Development of unconventional sources of natural gas (such as coal bed methane) in NZ may be restricted by cost, and environmental considerations (toxicity of fraccing chemicals, disposal problems of saline water etc.)

- **Municipal Waste Management** – solid and liquid municipal wastes can be processed and effectively managed using biogas technology. Combined heat and power (CHP) is a reliable, cost-effective option for municipal wastewater treatment. Biogas from onsite digesters can be used in a CHP system as "free" fuel to generate reliable electricity and power. Such facilities are critical for maintaining public sanitation and a healthy environment, and must be able to operate in the event of a natural or man-made disaster, as well as any utility power outage. Because of its ability to produce electricity and heat on site, independently from the grid, CHP is a valuable infrastructure addition for solid and liquid waste treatment.

- **Farm Wastes** – Coverage in the media of pollution associated with animal waste on farms is rarely positive but increasing. Anaerobic digestion is a tool enabling better farm waste management on dairy farms and piggeries. Biogas generation offers a significant advantage in being able to minimise odours, make nutrients contained in farm wastes more plant available, and allow for better timing of effluent land application. Biogas technology can help to make the farming sector more energy self sufficient, and allow farms to continue operating during power outages. Biogas recovery from farm wastes remains one of the very few practical and economical ways of reducing agricultural GHG emissions, both by minimizing fugitive methane emissions and substituting for fossil fuel derived heating and transport fuels or electricity.

- **Balance of trade**. Petroleum is New Zealand's single biggest import category, and likely to increase in coming years. Petroleum imports use up almost all export earnings made by the dairy sector. Without the petroleum import block, NZ would not have a current account deficit. Every small step that helps to reduce our dependence on imported petroleum is therefore very valuable for addressing our biggest economic problem – the current account deficit. Biogas transport fuel is the most efficient and effective transport biofuel available today, and can help to substitute a meaningful amount of our petroleum imports and current account deficit.

- **Air Quality –** Use of biogas has the potential in a number of situations (stationary and mobile energy use) to reduce emissions to air and improve local air quality. The use of biogas in public bus or rubbish collection truck fleets is only one example.

- **Nutrient recycling –** better waste management. World phosphorus supplies are becoming increasingly scare and less available, while the production of nitrogen fertilizers is an energy intensive process. Returning both P and N contained in digested originating from wastes that alternatively would have ended up in a landfill or waterway to agricultural land can therefore help to enhance our national phosphorus supply security, and preserve finite natural resources.

A 4 Biogas Stakeholders

The generation and use of biogas presents opportunities and benefits to a wide range of stakeholders including:

- **Waste Management Industry** - through effective management of solid and liquid waste treatment plants and landfills, the industry has the potential to minimise waste problems, generate renewable fuel, minimise wider environmental impacts including climate change.
- **Research and Development Sector** – The New Zealand research sector has a pivotal role to play in the development of technical solutions to meet New Zealand needs as well as ongoing activity on the international stage and in doing so ensure that New Zealand can take advantage of the latest developments. Cost effective, innovative and fit for purpose applications will be key.
- **National and Local Government** - The Government has a key role to play in assisting development of the sector financially and in ensuring that the most effective economic and regulatory framework is in place to facilitate and encourage opportunities for uptake. Local Government is at the front line in terms of its role in consenting applications and in managing local environmental impacts. Biogas presents councils with opportunities at the local level including reduced GHG emissions, security of local energy supply (individual sites), waste management, pollution control, odour management and business-specific biogas applications including transport and CHP. A requirement for generation at all landfills under council control will be a significant contribution here.
- **Transport Sector** – for niche route and onsite uses, biogas can be an alternative transport fuel. In the event of a fuel supply or price crisis, scale-up of AD using energy crops could supply enough fuel to meet a large part of farm and rural vehicle fuel needs.
- **Food Sector** – where scale permits, there is potential for food processors to use biogas generation as a means to ensure little or none of their waste ends up in landfills. The competition with wastes going to animal feed is acknowledged.
- **Farming and Rural Communities** – the production of biogas will make an important contribution to the farming sector and the communities it supports through the generation of renewable energy, the minimization of environmental impact (pollution and emissions to air (CO2, methane and odour)) and improved nutrition management. Farmers have the potential to generate additional economic benefits. Fonterra's work with farmers through the Dairying and Clean Streams Accord to ensure clean waterways will be of significant assistance.

A 5 New Zealand Biogas Expertise

New Zealand based organisations with expertise in biogas and actively engaged in the biogas industry are listed below:

A) Suppliers	
AECOM	Consulting Engineers: civil, energy, environmental - planning and industrial design
Auckland University	Research and consulting: combustion technology, transport engine development, fleet modelling
Bioform:	Consulting: agro business
BECA	Consulting Engineers: civil, wastewater, mechanical, environmental planning and industrial design
Clarke Energy	Equipment Suppliers: gas engines
CPG	Consulting Engineers: civil, mechanical, waste technologies, energy, environmental -planning and industrial design
Dieselgas	Engineering: vehicle engine conversions
Eastharbour	Consulting Engineers: energy planning
Entec	Equipment Suppliers: gas engines
Greenlane / Flotech	Equipment Suppliers: biogas upgraders, compressors
NIWA	Research and consulting: small scale biogas systems for wastewater and farm waste treatment, advanced biogas utilisation, improved AD nutrient reuse
PGG Wrightson	Advisors and Suppliers: agro business
Plant and Food	Research: crops, agro business

B) Operators	
Christchurch City Council	Operators: landfills, wastewater treatment plant, co-digestion, solids drying, biogas transfer network. New Zealand’s first biogas tri-generation plant
Dunedin City Council	Operators: Digesters and Landfills
Fonterra	Operators: wastewater digester and boiler fuel use
Hamilton City Council	Operators: digesters and gas engines
Palmerston City Council	Operators: digesters, gas engines, co-digestion
Transpacific Industries (NZ)	Operators: Landfills (Redvale, Dairy Flat, Whitford - Auckland, Rangitikei, Kate Valey, Porirua, Dunedin) Hosting pilot project: New Zealand’s first biogas powered rubbish truck.
Watercare	Operators: digesters and gas engines
Wellington City Council	Operators: landfills; sludge treatment
Lepper Trust piggery	Biogas CHP system based on pig manure digestion in covered anaerobic pond
Landcorp Rangiora	Biogas CHP system based on dairy cow manure digestion in heated mixed digester
Meat Processors	Operators: various pond digesters