Reducing greenhouse gas emissions to achieve "Zero Carbon by 2050" using biomass energy for industrial and commercial heat

1. Biomass is the most renewable and flexible fuel for heat

It is not unexpected that biomass is the most used renewable resource for production of energy[1] as it occurs nearly anywhere and more can always be planted. Biomass as a fuel is storable and can be transported to where it is needed. Hydro electricity is the only other renewable resource that has these attributes. Geothermal energy is location specific. Solar and wind energy is viable and are not storable.

Production of heat from combustion of biomass uses proven technologies.

The secret for maximizing the use of biomass as a source of energy is in how the biomass supply chain is developed and managed. To manage risks around the use of biomass for heating the users of biomass as fuel require reliable consistent supply.

Maximising the opportunities for transitioning from use of fossil fuels for heat requires building confidence in the biomass supply market. This is no different than development of any market.

Targets:

Proposed targets for the substitution of coal and gas fuels with wood fuels (above 2018 levels) based on a Transformational scenario are:

2030 8 PJ/year
2040 17 PJ/year
2050 20 PJ/year

By 2050 this equates to:

- **Converting around 34MW/year of existing boiler plant to use wood fuels**
- **Adding around 90,000 tonnes of wood fuel/year**
- **1.8Mt/year CO_2 eq emissions being avoided**
- **Cumulative savings of $4.5 billion in avoided cost of carbon at $50/t from other sources over the period to 2050 (most likely international markets)**

2. Using biomass energy to reduce greenhouse gas emissions is simple and already occurring

The Bioenergy Association has identified that bioenergy and biomass fuels for industrial and process heat can contribute significantly to greenhouse gas emissions reductions by 2050. Transition from use of coal and gas to using biomass for process heat is already well established across New Zealand. To achieve the maximum potential for greenhouse gas emissions reduction by 2050 requires only improvement of the efficiency of the biomass fuel supply market resulting in a speeding up of new investment in biomass fueled heat plant.

[1] 13% of total world energy demand. REN21 Renewables 2018, Global Status report.

Currently 11% of New Zealand's consumer energy (mainly process heat) comes from biomass and this could increase to 15% by 2050 without any need for research or significant investment. This would reduce greenhouse gas emissions by 3-6%.

Because of the nature of the market failures the work to address current market inefficiencies will require government assistance.

In addition to greenhouse gas reductions in the industrial and commercial process heat sectors biomass energy use for residential heating can reduce the demand for electricity. Biomass energy can also be used to generate electricity. These two opportunities are not covered by the analysis behind this report on industrial and commercial process heat. This report also does not address the opportunities for treating organic waste by anaerobic digestion to produce biogas which can be used to make process heat. The waste to energy opportunity is addressed in a companion report[2].

3. Addressing the market

This paper sets out what the Bioenergy Association considers is realistically achievable and summarises the advocated strategy and policy options for using biomass energy to contribute to net zero greenhouse gas emissions by 2050[3]. The transition is mainly of coal plant but some gas transition is also expected in the latter period to 2050.

Three strategy pathways (scenarios) were developed to identify what would have to occur to achieve these levels of greenhouse gas (GHG) reduction.

Greenhouse gas emission reduction from the use of biomass fuel for production of heat would lead to a significant reduction in the need for the Government to purchase international carbon units in order that New Zealand met its Paris Climate Change Targets. By 2050, under a transformational scenario, 20PJ of fossil fuel could be replaced by biomass fuel resulting in a greenhouse gas emissions reduction of 1.8Mt CO_2 – e pa.

By achieving these levels of greenhouse gas emission reductions the Government would be saving $45 million per year in avoided carbon costs by 2050. The cost of achieving such savings is likely to be much smaller than the accumulated benefits.

The production and delivery of process heat from biomass fuel uses proven technologies and there are many facilities that demonstrate the ease of transitioning from using fossil to biomass fuel and the financial viability of these investments.

The main barriers to greater uptake of the use of biomass energy are:

- The infrequent need to replace existing heat plant that is still serviceable using coal or gas;
- the real and perceived cost of switching to biomass fuels;
- the commercial availability of biomass fuel for some applications compared to coal and natural gas;
- the cost and ease of other renewable alternatives (e.g. electricity and the use of heat pumps);
- the location of the heat plant relative to fuel availability; and

[2] Refer to Bioenergy Association Information Sheet 47 – *The role of organic waste and biogas in the transition to low carbon economy in New Zealand*

[3] This document is an update and expansion of Bioenergy Association Information Sheet 32 *GHG emissions using biomass energy for industrial and commercial heat* first published in June 2016

- and inconsistent policy and price signals for public good externalities. Such externalities include greenhouse gas emissions, land use change and water quality.

The Emissions Trading Scheme (NZ ETS) will result in an increased value on carbon thus providing a market incentive to move from coal to biomass fuel for heating but will not address all short-term market failures and market development needs that are currently barriers to a greater use of biomass fuel for heating.

The impact of the NZ ETS will be slow coming so a faster replacement of fossil fuels for process heat will require specific programmes and policies to provide incentives to business.

Where natural gas is available in the North Island the relatively low cost of gas and gas heating equipment, compared to that for biomass energy, means that the impact from the increasing cost of carbon over time will be small until gas supply becomes constrained, or until the cost of carbon is very high, and is not expected to occur until close to 2050.

> **The Bioenergy Association recommends that the focus for growing the transition from fossil fuels for process heat is on ensuring the availability of biomass fuel with gradual growth in supply quantities driving by increasing demand from small and medium scale heat plant until sufficient fuel supply capacity is available is larger for heat plant.**
>
> **In the short-term encouragement of cofiring biomass and coal will allow some existing plant to start the transition.**

Biomass fuel supply will include plantation forestry harvest residues, agricultural and horticultural biomass and clean urban waste biomass. This will enable the biomass energy market to grow in an effective way and over time meet the levels and reliability of supply required for large heat plant to convert from coal, and then potentially natural gas, to biomass fuels. With improvements in the perception of the long-term availability of fuel the conversion of existing fossil fueled industrial and commercial heat plant to biomass fuels is an action that can be initiated now.

Furthermore, the Bioenergy Association agrees that the Government and local authorities must show leadership and start to convert their existing heat plant facilities as set out in the New Zealand Energy Efficiency and Conservation Strategy (NZEECS)4 and confirmed as necessary by the Productivity Commission5.

[4] https://www.mbie.govt.nz/info-services/sectors-industries/energy/documents-image-library/NZEECS-2017-2022.pdf

[5] *Low-carbon economy*, The New Zealand Productivity Commission, 2018

There is potentially enough biomass available from plantation forestry to replace 60% of coal used in existing heat plant over the next 30 years. The remaining 40% can come from new plantation forests (established as part of the 1 billion trees initiative; farm forestry; use of currently unused biomass eg straw; and electricity.

There is adequate biomass fuel but the market is under-developed because the current demand for biomass fuel is low. There are also enough suppliers with commercial and technical capability to expand supply if demand for biomass fuel increases consistently and in an orderly manner.

The amount of biomass required to replace natural gas is less certain because it is smaller and more distant in time. However, the quantities required will be within the capability of the 40% of additional sources of biomass.

In this context, the co-firing of larger coal plant with biomass is a useful transitional approach as the co-firing percentage can be varied based on biomass fuel availability, and gradually increased over time. In addition to this, for some sites with large coal fired heat plant facilities it may also be feasible to incrementally change heat plant facilities to use biomass fuels (for example partial conversion or the introduction of biomass fuel heat plant over a number of years).

The development of the local biomass fuel supply market is a precursor for eventual large-scale replacement of the fossil fuels with biomass fuels. It is typically recognised that heat plants using biomass fuels have higher initial capital costs and may incur additional costs with the purchase, handling and storage of biomass fuels compared to coal or natural gas fired heat plants. Even so, biomass energy can be the most economic option in many situations if total life cycle costs and other benefits are considered. Other significant non-energy benefits from switching from fossil to biomass fuel such as employment, regional economic growth and air quality are all public goods, which suggests that there is a role for Government in assisting industry sectors to transition from fossil to locally sourced biomass fuels.

Table 1: Current heating from biomass and fossil fuels

Fuel	PJ
Coal	23
Natural gas	78
LPG	6
Fuel oil	1
Diesel	7
Total fossil fuels	115
Biomass	54 *

*Includes black liquor biomass fuel used in the pulp and paper sector

Some low temperature heat applications could transition from fossil fuels to electricity using heat pump heaters. Medium temperature process heat can be supplied from electrode boilers. Electrode boilers are more compact than biomass fueled boilers and this is attractive on confined sites. They are also not complex technology and the fuel supply chain is simple. However the electricity is more expensive than biomass fuel. Electrical heat pumps have the potential to reduce the delivered heat costs below biomass costs - but have limitations at medium to high temperatures. In addition, every $1m of heat pump capacity requires at least $3m of electricity generation and network investments. Some of these network upgrade costs are likely to be transferred to the heat user. Currently wood fuels are about halve the delivery cost of direct electrical heating and about half the total capital investment cost per MWh of heat delivered.

Some existing fossil fueled heat plant could have the demand for existing fossil fuels reduced by efficiency improvements, cofiring or replacement by more efficient biomass heating. There is around $7bn of existing boiler assets that would need replacement but smarter use of biomass cofiring could reduce this capital burden on the heat sector by at least half.

4. The heat sector

The industrial and commercial heat sector comprises of a total of 6800 MW of heat plant capacity and there are around 2200 plants across New Zealand spread across a range of sectors including dairy processing, biomass processing, meat processing, other food processing, other manufacturing and hospitals (CRL Energy, 2014)[6]. In terms of current fuel types used for the industrial and commercial heat sector natural gas and coal heat plant make up over 60% of the total.

Wood fueled heat plant currently comprises of 20% of the total with most of these being used by the wood processing sector. Across all heat plants, Government or local government owned facilities make up around 58% of all heat plant and of these only 7% are currently using biomass fuels. Publicly owned heat plant make up 13% of the coal fired heat plant. The education and health sectors operate most of the coal fueled heat plants.

For many heat users their current coal or gas fired equipment has many years of serviceable life still available so for those owners it may be a number of years before they would even consider replacement unless a compelling driver occurs.

5. Target areas

Work undertaken by Waikato University has shown that the dairy and meat processing sectors are areas of priority with respect to reducing greenhouse gas emissions.

[6] CRL Energy, *2014 Heat plant in New Zealand*. CRL Energy Limited Report 14/11017.

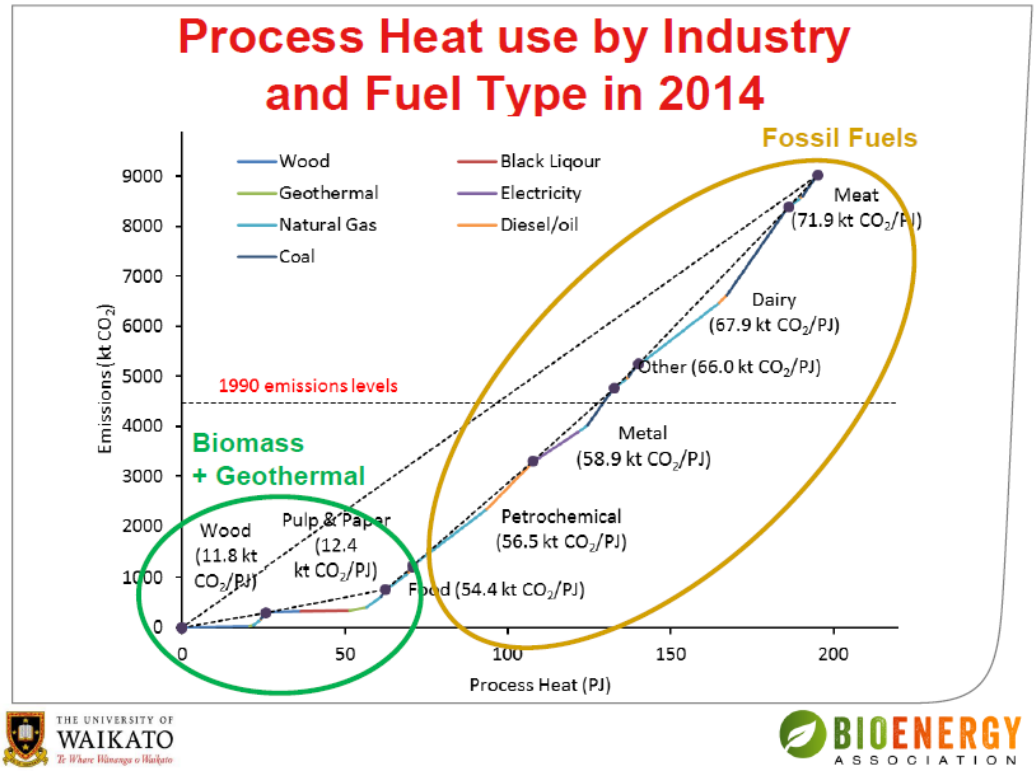

Figure 1: Greenhouse gas emissions intensity by sector

Reduction of greenhouse gas emissions and the move to using renewable energy in general is a public good as often there are minimal direct short term (i.e. 3 – 5-year timeframe) economic benefits for business to move from using fossil fuels to using low carbon options for heat. However when life cycle benefits and opportunities for 'shared value" arising from the use of biomass fuel instead of fossil fuels are considered there are increasingly a number of business situations where a shift is economic and beneficial for business sustainability.

The 'other' sector (in Figure 1) which includes government owned facilities such as hospital, schools, correction facilities and community swimming pools is a component of the heat market where central and local government can provide leadership and install heat plant using renewable biomass fuels. These are also facilities where the lifecycle economic benefits for Government as owner are greater than if the owners are in the private sector.

'Other' sector owned facilities are also ideal for assisting in creating economies of scale of fuel demand adequate to provide incentive for biomass fuel suppliers to scale up their operations. This will assist in providing confidence to large heat user sectors (for example, dairy and meat processing) that the biomass fuel suppliers can meet large demand for biomass fuel on a sustained basis. Furthermore, that these fuels can be reliably delivered and consistently meet the relevant fuel specifications.

6. Scenarios for Biomass Energy Expansion

Scenarios developed by the Bioenergy Association for growth in the production and utilization of biomass energy to reduce greenhouse gas emissions are:

Scenario 1: Business as usual (BAU)

Conditions:

- Based on existing policies and market conditions. No policy changes and the NZEECS policies are not implemented.
- Uses existing combustion technologies and an extension of current trends.
- Assumes current NZ ETS with the adoption of the 2 for 1 policy to ETS administration.
- Biomass fuelled heat plants continue to replace existing coal heat plants at the rate similar to current installation rates over the last 10 years through there is some increase as existing coal plant comes up for renewal/replacement or refit in the later years of the scenarios. Minimal gas plant is replaced with biomass fueled heating

Scenario 2: Transition

Conditions:

- Government implements the NZEECS which signals that it wants to encourage short term domestic GHG reduction so as to minimise the need to purchase international greenhouse gas mitigation units and to create some more certainty in the investment market for renewable energy.
- That Government follows through with the NZEECS and establishes a process heat programme based mainly on efficiency improvements and implements its plan of action.
- Government collaborates with forestry, waste and bioenergy sectors to implement the NZEECS and assists development and expansion of the biomass fuel supply market.
- Local government responds to the NZEECS and provides leadership and demonstration of opportunities.
- Government contributes funding to achieve public good benefits.
- Assumes heat plant owners have no incentive to replace existing serviceable equipment before end of life. Carbon is priced at $25/tonne CO_2 eq (2018) and is increasing at a consistent rate of 2.5% per year.
- Differences from BAU:
  - Limited number of complementary measures as set out in the NZEECS are pursued and implemented.
  - Government requires evaluation of heat plant capital investment options to be on a total life cycle value instead of a least capital cost basis.
  - Central Government introduces policies to change Government procurement so that renewable energy and efficient energy use options must be considered when making investment decisions for heat plant and all additional benefits are included in the full life cycle analysis of options. Typically this full life cycle analysis will consider the next 30 years (i.e. out to 2048).
  - Government sets targets for the heat market to achieve specific reductions in GHG emissions and monitors progress to achieving the targets.

  - Government's project appraisal models use a projected higher CO_2 cost than the private sector may be exposed to under the ETS, in line with MBIE's "Medium" scenario of $25-50/tonne. (This approach/modeling is justifiable as it will be demonstrating that the Government is taking clear long-term decisions that reflect the likely real price of carbon over the life of the assets.)
  - Local councils are required to introduce similar central Government procurement policies for their own purchasing or replacement of heat plant.
  - Government adopts a collaborative growth strategy with the biomass energy sector based on reducing GHG emissions by using biomass fuels instead of coal for industrial and commercial heat. (Minimal gas fueled heat plant replaced by biomass fueled heat plant).
- Government procurement relies on the ETS as a surrogate for externalities – i.e. the new policies are complementary measures that significantly lift the use of renewable energy for GHG emission reduction.
- Medium sized plants are the initial focus for changing to biomass fuels so as to grow the biomass fuel supply market – but this changes with time to allow a shift to conversions for larger heat plants.
- Co-firing with coal and incremental replacement of heat plant using coal are accepted as a transition pathway and as a means of growing the biomass fuel supply market and transitioning some serviceable coal plant to using biomass fuel. This is a means of overcoming the reality that much coal fired heat plant still has many years economic life that a business wants to make use of.
- Biomass fuel supply market growth is assisted by education and accreditation packages. (No constraint on fuel availability if the focus is on medium sized plants and given that around potentially 20 PJ of available biomass fuel has been identified nationwide out to around 2035).
- New biomass fueled plant is recognized as being more efficient than existing coal fired plant and operators opt for heat storage systems to achieve additional energy efficiency.
- Some conversions opt for replacement with electricity, in particular for low temperature hot water.
- Heat plant optimisation improves the efficiency of existing plant and reduces the need for some quantities of fuel.
- Air quality standards and regional consenting policies are improved and are not barriers to the use of biomass fueled plant in any regions throughout New Zealand.

Scenario 3: Transformation (for GHG reduction, environmental and economic outcomes)

Conditions:

- The conditions of scenario 2 are achieved plus the following additional considerations.
- Government aims to maximize the opportunities for domestic greenhouse gas emission reduction to either markedly reduce or avoid the need to purchase international carbon trading units; and pursues its environmental and regional growth objectives.
- Government seriously considers and adopts in 2019 some complementary measures to the ETS and extends the NZEECS at the next review in 2022.
  - Accelerated depreciation for greenhouse gas emission reduction projects

- Suspensory loans for greenhouse gas emission reduction projects.

- Government, forestry and biomass processing sectors develop a collaborative approach to maximizing the value from forestry, its role in mitigating against reduced water quality and soil loss and significant additional tree planting occurs from 2018.
- Some farms adopt a food plus fuel business philosophy. Those farms start offsetting their biological emissions by working collaboratively with biomass fuel supply aggregators and other neighbouring farms to contract for supply of biomass for treatment into specification quality fuel and delivery to nearby biomass fueled heat plant.
- Carbon is priced at \$50/tonne CO_2 eq (2020) and it is increasing at a consistent rate of 5.0% each year.
- Some natural gas, or LPG fueled plant is replaced by biomass fueled plant because of increased gas price due to gas field supply constraints.

Differences from scenario 2:

- The Government's project appraisal models use a projected CO_2 cost, in line with MBIE's "High" scenario of \$100/tonne.
- Additional low-cost policies are introduced to address barriers specific across sectors and within a sector such as accelerated depreciation on capital expenditure and the introduction of suspensory loans to reduce the effect of current capital cost barriers.
- Government sets challenging targets for the heat market to achieve specific reductions in GHG emissions.
- Government does an annual cost-benefit of forward offshore purchase of GHG obligations compared to acquiring domestic mitigation through a capital fund which funds through suspensory loans the public good component of transitioning to biomass fuel.
- The Government continues with capital grant schemes as part of regional development programmes similar to Southland's Wood Energy Programme.

- Government encourages additional domestic added value processing of wood with the consequence that greater volumes of high quality biomass fuel become available.
- The Government, local authorities, and communities value the intangible benefits of biomass energy (for example economic development, environmental improvements and energy resilience and security).
- Farm forestry is recognized as being a viable source of biomass fuel driven by environmental and commercial benefits for farm resilience.
- Government does not wait for new research to initiate strategies to reduce GHG emissions.

Note: Scenario 3 is based on economically rational decision making by investors and fuel suppliers. Greater amount of conversion could theoretically be achieved but this would require stronger Government intervention such as mandated targets, fuel subsidies or renewable energy credits. The scenario is within the New Zealand wide biomass fuel supply capability without using arable land.

7. Scenarios for Using Biomass Fuel for Heat

7.1 Substitution of fossil fuels with biomass fuels

Focusing on the replacement of fossil fuels by biomass fuels is a very cost-effective way to reduce GHG emissions and achieve other economic development objectives. Furthermore, coal fired heat plants represents around 22% of the total nation-wide heat plant capacity, but around 30% of heat plant that potentially can be converted to biomass fuel by 2050. Although natural gas fuels 38% of the total heat plant capacity, it is generally regarded that conversions of heat plant fueled by natural gas to being fueled by biomass fuel are going to be substantially more difficult to justify compared to conversion of coal fired units. However some conversions is anticipated in Scenario 3 by business adopting sustainable production practices. Other fossil fuels such as diesel, LPG and Light Fuel Oil (LFO) fuel less than 8% of the total heat plant capacity and are generally used for small scale heat plant. Many of these that are low temperature could possibly be converted to using electricity for heat. The Bioenergy Association scenarios focus on the conversion of existing coal heat plants to biomass fuels as these are heat plants most likely to contribute to meaningful GHG emission reductions over the next 20 - 30 years.

Based on scenarios for converting existing fossil fuelled heat plant[7] under the transformational scenario (Scenario 3), which aligns with the proposed strategies and policy of zero carbon, it is expected that up to 20 PJ/year of coal and gas could be replaced by biomass fuels by 2050 (Figure 2). The BAU and transition scenarios will not meet the objectives of zero carbon by 2050.

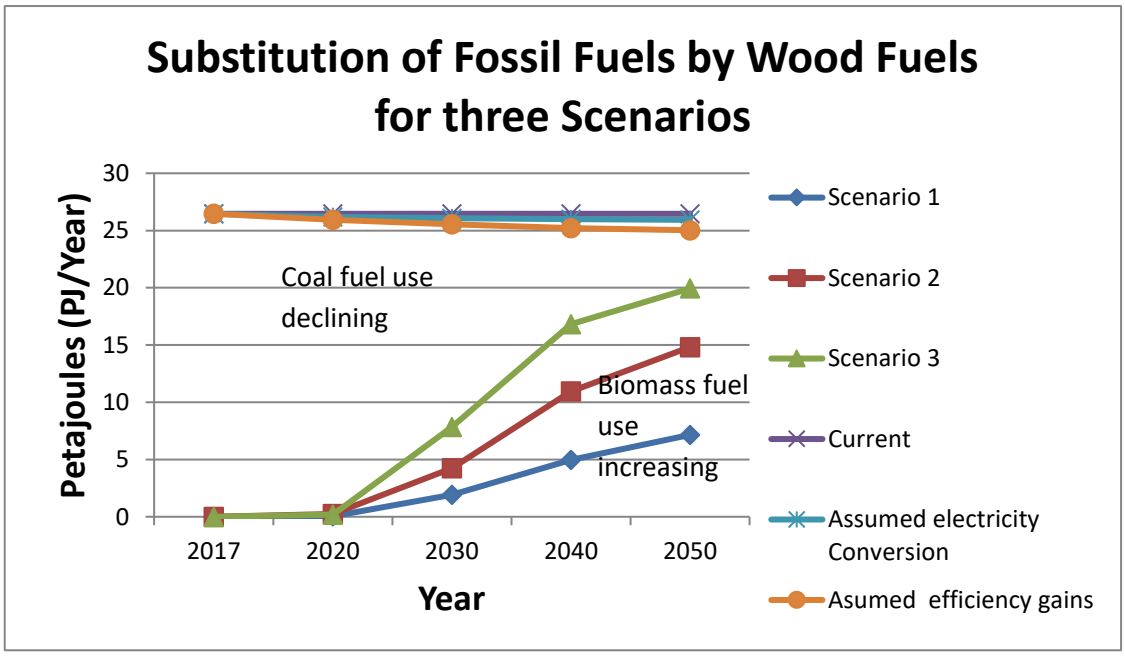

Figure 2: Scenarios for the substitution of fossil fuel by biomass fuel

The three scenarios in Figure 2 are:

Scenario 1 - Business as Usual;
Scenario 2-Transition (Implemented NZEECS); and
Scenario 3 - Transformation (maximising GHG reduction, environmental and economic outcomes).

[7] Note there are no assumptions or consideration to totally new greenfields biomass fuelled plant which would be additional to the analysis results in this document

Figure 2 includes the assumption that some low temperature heat plant may be converted to electricity and that there will also be some reduction of the use of coal due to heat plant efficiency gains for existing heat plants. Conversion to electricity was assumed to be around 1-2% over each decade period for low temperature heating of mainly small sized plant. Energy efficiency was assumed to vary between 1–3.5% over the analysis period. The current line represents the total amount of energy produced from existing coal fired heat plant in New Zealand currently. This analysis has assumed that there is no new plant built so if this were to occur it would be additional to the results shown in Fig. 2.

Scenario 3 includes some replacement of gas fueled heat plant by biomass fueled plant.

7.2 Targets

Establishing targets for the conversion of fossil fuelled heat plant to use biomass as fuel will provide goals for development, implementation of policies and a framework for investment decisions across the industrial and commercial heat sectors.

As a result of the analysis results shown in figure 2, the Bioenergy Association recommends targets for the substitution of coal and gas by biomass fuels above 2018 levels as shown in Table 2.

These targets are based on the Transformation Scenario (Scenario 3) which aligns with the ambitious goal of zero carbon by 2050. Because of the relative economics the majority of conversions will be coal but some allowance has been made for conversion from gas fired heating because there are a number of companies currently using gas will transition either for sustainability/climate change reasons or because of growing uncertainty on the future supply of natural gas.

Table 2. Recommended targets above 2018 for the substitution of fossil fuels by biomass fuel based on the transformation scenario (PJ/Year).

Year (Decade)	Target substitution above 2018 (PJ/year)
2030	8
2040	17
2050	20

From a policy point of view and to maximise the amount of greenhouse gas emissions reduced by 2050 and to achieve net-zero emissions by that date it is recommended that scenario 3 should be pursued by Government as a minimum. Greater greenhouse gas emissions reduction beyond that of scenario 3 is possible but would require significantly stronger Government intervention such as fuel subsidy, mandatory targets or renewable energy credits as are used in most other countries.

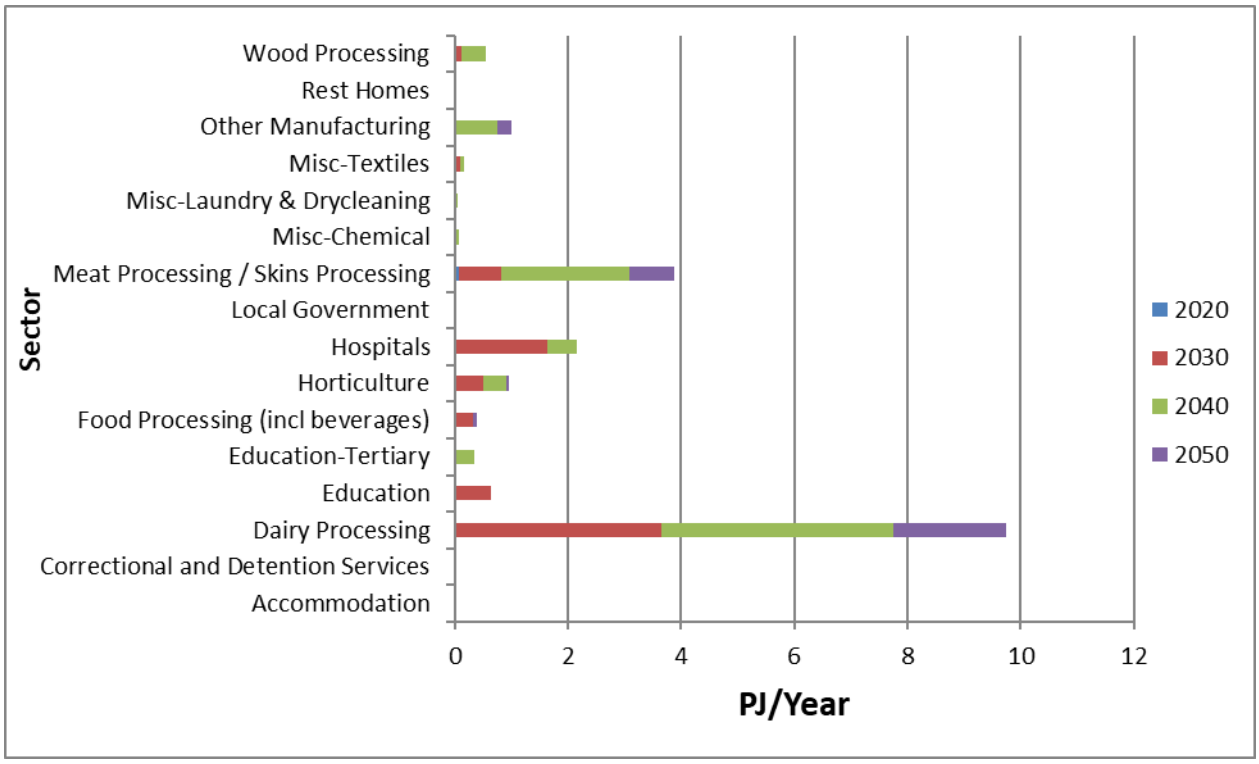

Figure 3. The contribution of each sector to the substitution of fossil fuels by biomass fuels for the Transformational Scenario (Scenario 3).

The sectors likely to contribute to achieving these targets are Meat Processing, Dairy and Hospitals (figure 3). Though these sectors are not likely to start to contribute until well after 2020 and with the most significant levels of coal substitution occurring in the decade from 2030 to 2040. The Government and local government sectors could contribute 0.1, 2.3, and 0.9 PJ/year for period to 2020, and decades to 2030, and 2040, respectively. By 2050, the Government sector would largely be using renewable biomass fuels so by this time its requirement to change would be diminishing markedly. The Government and local government sectors comprise of correction and detention facilities, education (e.g. mostly schools), hospitals and local utility building facilities. The Government and local government sectors have been assumed to be taking major leadership role in the implementation of biomass fuel heat plant (refer to Annex 4 for further information related to the role of the Government sector).

Fossil fueled heat plant less than 0.5MW in size that are able to be converted to renewable energy are likely to become fueled by either electricity or biomass pellets. The current biomass pellet production capacity is adequate to meet likely demand for pellet fuel.

With only increased marketing heat plant in the 0.5 - 2 MW range can provide the initial shift to biomass fuels over the early period as existing fuel supply chains are already adequate. As the capacity for biomass fuel supply expands then this leads to greater opportunity to convert heat plants of 2-10MW and >10 MW. Heat plants over 10 MW include those from the meat processing and dairy sectors but are infrequent investments. For these facilities it has also been assumed that the full heat supply capacity is not provided by biomass fuels in the short term due to constraints in the biomass fuel supply and thus cofiring with coal is likely as a transition to greater use of biomass fuel over the first 20 years. By 2050 biomass fuels are taking over completely from the use of coal for these larger heat plants.

Table 2. The contribution of each heat plant size category for each decade for the Transformational Scenario (Scenario 3 (PJ/year).

Heat Plant Size	2020	2030	2040	2050	Total
< 0.1	0	0	0	0	0
0.1-0.5	0	0.02	0	0	0.02
0.5 - 2	0.04	0.92	0.16	0.03	1.15
2 -10.	0.08	1.93	1.98	0.52	4.51
>10	0.06	4.79	6.83	2.58	14.26
Total	0.18	7.66	8.97	83.13	19.94

7.3 Projected Biomass Fuel Demand

The biomass fuel demand required to achieve the proposed targets for the Transformation Scenario (scenario 3) is 1.4 million tonnes per year by 2030, 3 million tonnes by 2040 and 3.6 million tonnes by 2050. Current biomass fuel forecasts indicate that there is around 2 million tonnes of biomass fuel currently available out to 2040 but additional sources of biomass fuel will be required to reach the higher demand levels by 2050 for Scenario 2 and 3. This is considered achievable with more planting by the forest sector provided planting is able to be harvested. (Planting of native trees which are not so readily harvested may lock up land suitable for revenue earning where fuel could be produced).

In addition the increased demand for biomass fuel will provide an incentive for some farms located near heat plant to expand from being solely food producers to food plus fuel providers. Farm forestry is already firmly established throughout New Zealand and the drivers of having biological emissions offsets, reduced nutrient runoff into waterways and biomass fuel from shelterbelts, wood lots and riparian planting will improve farm business resilience.

Short rotation biomass crops including miscanthus and wood species can provide farmers with an annual cash flow which is missing from long rotation species. However long rotation wood species are most ideal for hilly terrain. There are also quantities of agricultural waste such as corn stover, straw etc which can be pelletised and used as biomass fuel. In many countries such as China these sources of biomass are more common than wood fuel.

The scope for cofiring biomass fuel with coal can be broadened by torrefying the biomass so that it more closely resembles coal. This can improve combustion but in addition because torrefied biomass pellets are not hydroscopic the need, and thus cost, for dry transport and storage is reduced.

Cofiring high grade fuel (pellets) with low grade hog fuel or bark is also a method for being able to combust cheaper low-grade fuels which would otherwise be left in the forest or disposed of to landfill.

While greater quantities of biomass suitable for processing into fuel can be recovered from plantation forests there will need to be a commercial driver for forest owners and contractors for this to occur. This is likely to come about once the size of the biomass demand becomes big enough. Transition to a sector focused on gaining the highest value from forestry instead of being content with export of low value logs as a commodity will provide a significant driver. Bio-based materials from biomass will be a replacement for petroleum derived plastics etc. As the cost of petroleum increases again this will come about but is not expected to occur until the 2030-50 period.

The sale of biomass fuel is in its infancy as until recently biomass fueled heat plant was fueled from material sourced on-site e.g. sawmills. As heat plant owners without direct access to biomass fuel eg hospitals, schools have transitioned from fossil fuels the market has required third party fuel suppliers to become established. Expansion in the demand for biomass fuel will require expansion of these suppliers. It is a specialist business as the suppliers aggregate biomass from a wide range of sources and treat it to become specification compliant fuel. Growth in the fuel supply market will need to be orderly if it is to avoid the often boom / bust outcomes that industries which grow too fast can experience.

The analysis of biomass fuel availability shows that there would be adequate quantities to convert 100% of fossil fueled heat plant by 2050 but each of the fuel supply initiatives outlined above would have to be progressed and this will require Government assistance and leadership if it is desired to occur earlier.

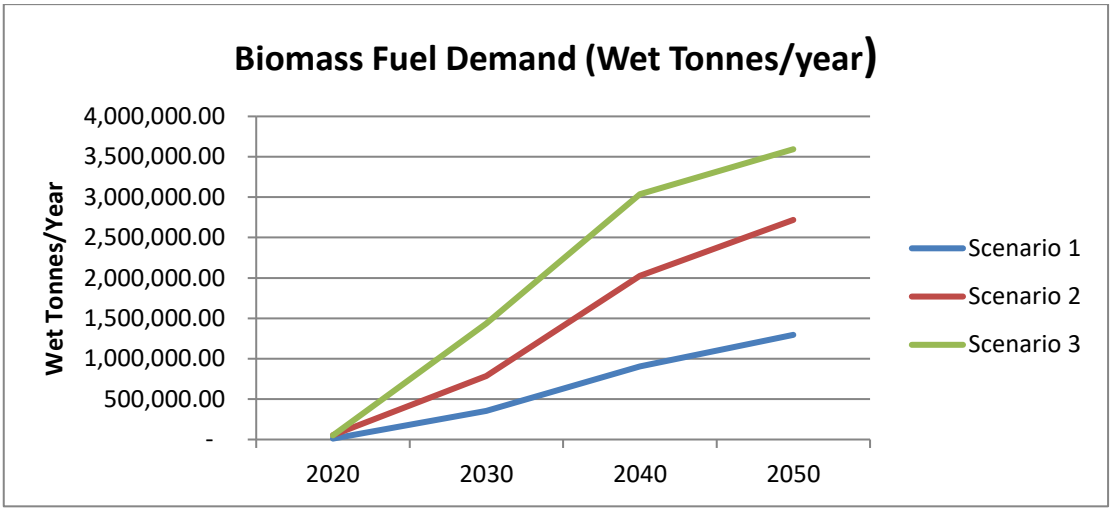

Figure 4. Biomass fuel demand for each scenario out to 2050 (wet tonnes/year).

Note: The assumptions used to determine the biomass fuel demand are based on a sector specific load factor, 75% efficiency and a biomass fuel calorific value of 7.5 GJ/ tonne wet fuel.

7.4 Projected GHG emission reductions

The greenhouse gas emissions reductions projected to rise above 2018 levels principally from the substitution of coal by biomass fuels are 1.5 MT CO_2 eq by 2040 for the Transformation scenario, and this increases to 1.8 Mt CO_2 eq by 2050 (Figure 5).

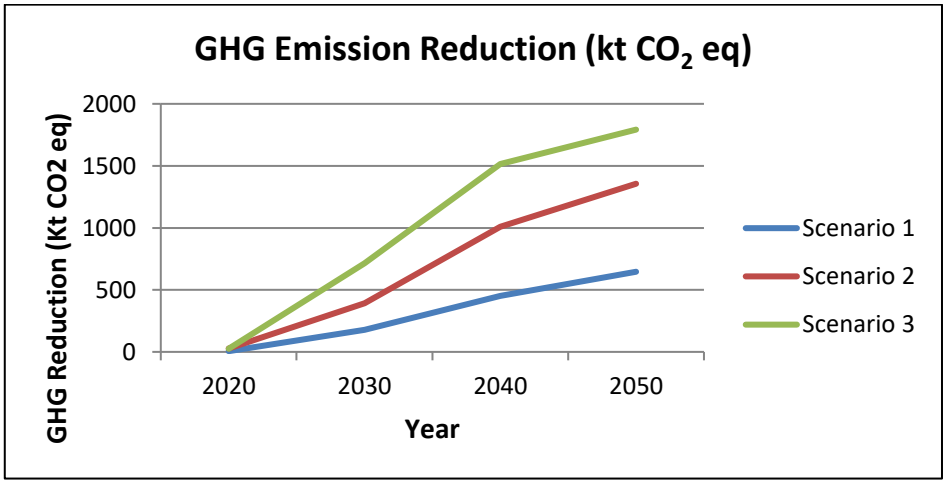

Figure 5. Greenhouse Gas emission reductions for the three scenarios (kt CO_2 eq).

7.5 Wider benefits of conversion to biomass fuel

The additional benefits arising from the proposed GHG reduction measures for the industrial and commercial heat sector are significant:

- Multiple national and local benefits – and not just the supply of energy:
  - National and regional economic growth (new factories, local jobs, etc);
  - Business growth and financial resilience (cost effective renewable energy);
  - Environmental: reduced emissions to air, waste reduction, and improved water quality due to land use change from pasture to forest and other crops;
  - Clean, green, low carbon economy supporting 'green' products in international markets.
- Additional value for forest & land owners:
  - 10-15% of forestry fibre can be wasted (so a major opportunity, especially for Iwi as emerging forest owners);
  - Opportunity for farms to produce food plus fuel;
  - Opportunities for farms to offset biological emissions;
  - Improve farm business resilience.
- Economic growth from world leading fibre-growing conditions:
  - Transition to a bio-based economy to replace petroleum derived plastics etc.
  - Enhanced opportunities for bio-oil, bio-chemicals, bio-plastics etc ("Bio-materials");
  - The possible development of bioenergy centres where biomass fuels, bio-oil, biogas and liquid fuel systems are integrated and supplying multiple services and benefits.
  - Co-products with traditional farming contributing extra revenue streams for farmers.
- However market failure because most benefits are public goods mean the highest value for biomass is not currently being realised:
  - A "Rational Choice" for a company is not the same as a rational choice for New Zealand;
  - Energy users don't care about non-cost benefits (jobs, energy diversity etc);
  - Selling commodity logs to Asia minimises economic benefits, and exports employment opportunities;
  - Increased added value processing of wood within New Zealand produces economic value for NZ through the creation of jobs and higher value export products, plus high quality biomass fuel for heat.

8. Barriers

The fact that the primary benefits of transition from using fossil fuels to using renewable fuels, to produce heat energy and thus reduce greenhouse gas emissions, is a public good makes it difficult for private sector heat plant owners to justify making the change. However industry has shown by recent decisions to move from using fossil fuels to using biomass fuel that the private benefits in niche applications can justify the move. The encouragement policies in the NZEECS (Scenario 2) will be enough to shift a number of other potential substitution projects over the line and to get them committed to by the private sector.

Trading in biomass fuel is new and still not often undertaken so the biomass fuel supply sector can be said to be still in its infancy. Until recently heat plant owners using biomass fuel have generally been able to supply the fuel from their own biomass processing operations. With the entry of heat plant owners who have to purchase biomass fuel there are all the elements of market development that have to be established e.g. standards, contracting best practice, perceptions of future fuel availability and market price knowledge.

The Bioenergy Association recognises that there are a range of potential customers for biomass fuel. These are summarised in Annex 1.

Heat plants are significant capital investments and can have economic lives of around 30 years so replacing heat plant equipment is not undertaken very often. When it is done the decisions are often based on a 15-30 year time frame risk analysis. The consequence is that the decision-making time frame for potential substitution is long term. There is also a lot of work required from identification of a need and commissioning of any new plant. This can often be over a period of 5-10 years. As a consequence the substitution projections for the Transition and Transformation scenarios are skewed towards the latter decades as policy changes and consequential behaviour changes by investors also take a number of years to achieve.

Access to capital for investment in new heat plant is a significant internal barrier because such investment is in competition from production focused investments. Policies to assist this will improve investment. However, it is expected that having a predictable and secure supply of biomass fuel will be the main barrier to address (See section 5.3 above).

9. Key Drivers

- Public support statements from Government/Ministers will encourage new thinking by forest and biomass products sector, farmers and investors.
- Adoption by the forestry and wood processing sector of strategies and research to achieve maximum value from wood rather than being content to sell ow value commodity products to Asia.
- Farmers being assisted to take up the opportunities for being producers of food plus fuel:
    - Identifying and demonstrating the financial and environmental benefits for farm resilience
    - Establishing regional hubs for aggregating biomass from a number of neighbouring farms.
- The switch from fossil fuels to use of biomass fuel provides significant public benefits with regard to climate change and transitioning to a low carbon future.
- Adoption of policies for government and local body procurement of biomass fuel heat plant would:
    - Move government agency decision making from short term least capital cost focus to lifecycle analysis resulting in fit for purpose decision making which is based on long term outcomes;
    - Provide economies of scale for the biomass fuel supply market to grow;
    - Demonstrate that the Government is serious about addressing climate change and with this setting up for growth of the bio-economy;

    - Provide demonstration to private sector heat plant owners of the ease and low risk of switching from coal and gas to biomass fuel.
- Assisting coal fired heat plant owners cofire biomass fuel
    - R&D and demonstration of cofiring biomass and coal in existing equipment;
    - R&D into torrefaction of biomass to produce fuel;
- The efficiency of the biomass fuel supply market would be improved by;
    - Increased demand for biomass fuel from a greater number of heat plant owners;
    - Quantification of the economic, environmental and social benefits of biomass fuels compared to fossil fuels through full life cycle assessments;
    - Increased domestic processing from the forestry and biomass products sectors which will increase the availability of biomass residues and quality of biomass fuel supplies;
- Greater assistance provided by the establishment of funding mechanisms to support the transition to renewable energy:
    - Accelerated depreciation;
    - Reinstate, and ideally boost, the EECA biomass energy programme;
    - Suspensory loans.

Detailed recommendations to achieve the targets identified in the Transformational Scenario are set out in Information Sheet 46 '*Actions to reduce use of fossil fuels for process heat and achieve net-zero carbon emissions by 2050*'.

For further information contact: Executive Officer, Bioenergy Association. Executive@bioenergy.org.nz

Annex 1: Biomass Fuel User Categories

Market drivers	Categories	Fuel source	User	Focus
Direct Heat from biomass	(Domestic) Micro heat plant <0.1MWt	Purchase firebiomass and pellet fuel	Private	• Air quality regulations • Installation standards, consenting • Installer accreditation • Generic marketing
	(School scale) Very small 0.1-0.5MW_t	Purchase pellet fuel and chip	Government, schools and rest homes etc	• Link to Ministry of Education • Information on options • Conversion vs new
	Small heat plant 0.5-2MW_t	Purchase pellet fuel and chip	Government facilities	• Work with Ministry of Health and l advisers • Air quality regulations
	(Commercial scale) Medium heat plant 2-10MW_t	Own biomassfuel	Wood processors	• Support owner/operators • Air quality regulations
		Purchase solid biofuel (chip and pellet fuel)	Govt facilities	• Work with Ministry of health, Corrections • Air quality regulations
			Food processing	• Support owner/operators • Air quality regulations • Link to waste to energy opportunities
			Horticulture	• Promotion of applications in horticultural magazines • Air quality regulations • Contribution to plant growth
	(industrial scale) Large heat plant 10< MW_t	Own biomassfuel	Wood processors	• Support owner/operators • Air quality regulations
		Purchase solid biofuel (chip and pellet fuel). Torrified biomass	Food processing	• Develop biomass fuel supply market through focus on medium scale heat plant so that adequate availability of fuel • Support coal/biomass fuel mix • Air quality regulations.

Annex 2: Assumptions

The assumptions for the biomass energy GHG reduction scenarios are:

Note these assumptions are reflected in the number of existing plants that are currently coal fueled and which are converted to biomass derived fuels.

Business as Usual: Scenario 1
• Over the period 2017 - 2050 around 0.21PJ/year of new substitution of biomass fuel for coal is occurring. This requires around 35-40,000 tonnes/year of wet biomass fuel to come on stream. This is driven by the requirements to meet the Paris agreement but with minimal intervention by the Government and the price of carbon remains at around current levels (i.e. less than $20 per tonnes CO2 eq.
• No new (greenfields) heat plant uses coal.

Transition (Scenario 2)	**Transformation (Scenario 3)**
• Wood fuels includes all form of fuels derived from biomass and herbaceous materials and may include biomass residues, torrefied biomass, Miscanthus, bio-oil, pellets and producer gas. Wood residues and other fibrous materials are expected to be the main fuel supplies.	• As for Scenario 2
• A total of 372 heat plant conversions from coal fuels to biomass occur over the period 2016 - 2050.	• A total of 372 heat plant conversions from coal fuels to biomass occur over the period 2016 - 2050.
• Over the 33 years being considered for the different scenarios all the current coal fired heat plant will be renewed and a selection of the smaller heat plant will be converted to electricity (low temperature hot water systems).	•
• Some of the larger heat plants (in particular for the diary and meat processing sectors) start to transition to biomass fuels using a range of strategies which will include the adoption of co-firing coal and biomass fuels and incremental conversion of the different heat plant on site.	• As for scenario 2, but there is an acceleration of the use of biomass fuels by the diary and meat processing sectors.
• Coal co-firing is being used at appropriate sites	• As for scenario 2
• All sectors are encouraged to switch to biomass fuels - but there is an emphasis on the Government facilities which tend to have smaller capacity heat plants.	• The dairy, education, meat and biomass sectors are the main sectors to take advantage of the depreciation regime for the period 2020 – 2040. Larger plants are able to come online due to improved security of biomass fuel supply.
• Emission factors for GHG emissions of different fuels derived from Ministry of the Environment voluntary reporting guidelines	• The emission factors as for scenario 2.
• That the heat plant providers are not constrained in the supply of heat plant (i.e. there is spare capacity in the heat plant delivery and installation supply chain). Wood fuel can be supplied effectively where it is required.	• As for scenario 2.
• By initially focusing on the small plants and developing the biomass fuel market (where biomass fuels can be delivered more cost effectively) then this encourages an increase in the larger non Government related boilers to be converted to biomass fuel.	
• The conversion to biomass fueled heat plant reduces after 2040 because the ‘easy’ to convert plants are reduced.	
• Electricity and geothermal heat were not included in this analysis.	

Annex 3. Comparison between the contributions of Government owned heat plant and privately-owned heat plant to energy arising from the use of biomass fuels.

The Government commercial heat sector is expected to provide leadership and be an 'early adopter' of biomass fuel heat plant. By the Government sector taking such a leadership role, then this will encourage the biomass fuel supply sector to develop and provide more commercial security for the private sector to move from coal to biomass fuels. The figure below indicates that by the Government encouraging the use of biomass fuels then this will facilitate significant growth in the use of biomass fuel derived energy in the private sector.