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New Zealand Country Report

IEA Bioenergy Task 33

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1. The Government Energy Strategies and Schemes

1.1. New Zealand Energy Strategy (NZES) 2011-2021

The NZES (MED 2011) was released on 30 August 2011 to replace the 2007 version. It provides the strategic direction for supply and use of energy to contribute to the growth of New Zealand economy for the benefit and well-being of all New Zealanders.

- The goal is to make the most of its abundant energy potential through the environmentally responsible development and efficient use of the country's diverse energy resources.
- The aim is to achieve a 50% reduction in our greenhouse gas emissions from 1990 levels by 2050.
- It proposes four priorities for achieving the goal:
  a. Development of resources;
  b. Securing and supply of affordable energy;
  c. Efficient use;
  d. Environment responsibility.
- The country has abundant renewable energy resources including hydro, geothermal, wind and biomass.
  a. Government is committed to the target of 90% of our electricity generation from renewable energy sources by 2025 (currently it is 79% mainly from hydro).
  b. Government joined in the International Renewable Energy Agency, effective on 1 May 2011.
  c. Government will continue to ensure market incentives and regulatory framework support for further investment in appropriate renewable projects by removing unnecessary regulatory barriers.

1.2. NZ Energy Efficiency and Conservation Strategy (NZEEZS) 2011-2016

The NZEEZS (MED 2011) is a companion to the NZES. It aims to encourage energy consumers to make wise decisions and choose efficient products. The energy efficiency target is to achieve energy intensity improvement of 1.3% per annum through the following four key sectors.

- **Transport**, a more energy efficient transport system, with a greater diversity of fuels and renewable energy technologies: 29 PJ of savings by 2015 or 4% fuel saving improvement from 2008 levels in GJ/kilometres travelled on land.
- **Business**, enhanced business growth and competitiveness from energy productivity investment: 21 PJ of savings by 2015 or 14% improvement in the commercial and industrial sector energy intensity level (GJ/$1000 of GDP).
- **Homes,** warm, dry and energy efficient homes with improved air quality to avoid ill-health and lost productivity.
- **Products,** greater business and consumer uptake of energy efficient products.

1.3. Emissions Trading Scheme (ETS) 2008 (amended in 2009)

The ETS (Climate Change Inf. 2011) is a way of meeting New Zealand's international obligation for climate change by putting a price on emission and providing an incentive to reduce emissions and to encourage tree planting. The purpose is to reduce the amount of greenhouse gases emitted in New Zealand by charging those who emit greenhouse gases while doing certain activities.

- Reduction of emission can be achieved with investment in clean technology and renewable power generation, and planting trees.
- Emission price was set at NZ$25/unit with current price being half of that at NZ$12.50/unit (one unit is equal to 1 tonne emission of CO_2 equivalent). However, it is under review by an ETS panel who recommended a current price of NZ$12.50/unit and increase to NZ$25/unit gradually by 2015 as shown as the black line in Fig. 1.

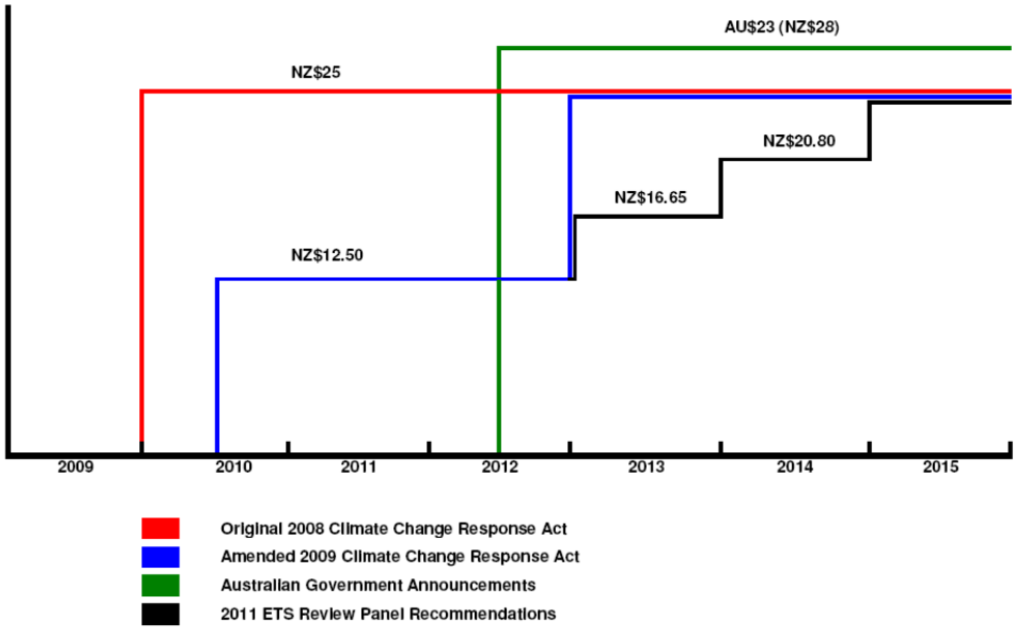

Fig. 1. Transition and timing of carbon pricing

1.4. Bioenergy Strategy 2010

The Bioenergy Strategy (BANZ et al 2010) was launched by non-government organisations including the Bioenergy Association of New Zealand (BANZ), the NZ Forest Owners Association and five forestry related companies.

- It aims to achieve economic growth and employment, and realise greater value from New Zealand's existing forestry resource and new energy crops by providing impetus to the growing bio-economy.
- Its target is to lift the national growth in bioenergy use by 2040 to 25% of consumer energy, substantially above its current 8.5%.
- This growth is driven by increasing domestic demand for heat from proven wood fuel and biogas technologies, and for transport fuels in the form of biogas, biodiesel or bioethanol. This includes a 60% increase in NZ's use of biomass for heat.

- The above target was estimated based on the existing and potential biomass resources and technologies, which will be implemented in three phases.
  a. Foundation building phase (2010 - 2015).
  b. Development phase (2015 - 2020).
  c. Expansion phase (2020 - 2040).

2. Biomass resource estimated

New Zealand consists of North Island, South Island and a few small islands with a total land area of 26.77 million ha (or 267,707 km²). The projected population is 4.4 million currently (Statistics NZ et al 2010). The land is used mostly for forest, pasture and agriculture as shown in Fig. 2 (NZFOA et al 2010). This means there are plenty of forest harvesting residues, wood processing residues and agricultural residues as biomass resource.

For the biomass resources, attention should be paid to the plantation forest of 1.79 million ha (NZFOA et al 2010) and grain crop area of 0.13 million ha (Statistics NZ 2008). The distributions of forest and grain crop plantation are illustrated respectively in Fig. 3 and Table 1. Central North Island (CNI) stands out as the largest forest plantation area, accounting for 30% of the national plantation forest, while Canterbury has the largest grain crop area, accounting for 65% of the national total. The distribution of biomass resources follows a similar pattern by region to the plantations.

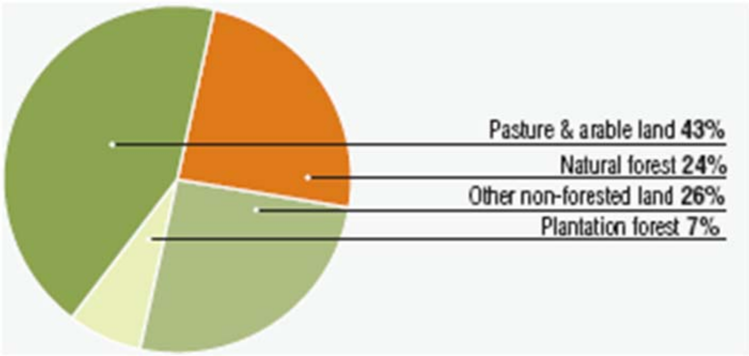

Fig. 2. NZ land use

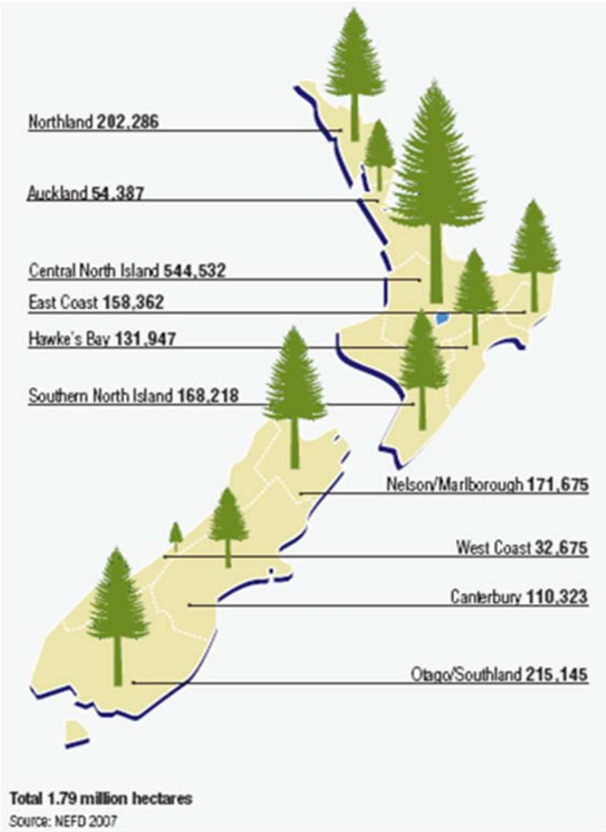

Fig. 3. NZ plantation forest distribution map (NZFAO et al 2010)

Table 1. NZ grain crop area by region in 2008 (Statistics NZ 2008)

Region	ha
Northland	700
Auckland	1,100
Central North Island	8,300
East Coast	2,800
Hawke's Bay	5,600
Southern North Island	11,400
Total North Island	29,900
Tasman/Nelson	Not available
Marlborough	500
West Coast	nil
Canterbury	81,000
Otago/Southland	14,400
Total South Island	96,500
NZ Total	126,400

2.1. Collectable Forest harvesting residues

Forest harvesting residues are the residues at landing and cutovers on the forest floor which have been estimated using proportion of the residues to harvested logs and the log production as well as harvesting systems. Fig.4. shows the estimation and prediction of collectable forest residues from 2007-2040 in the country and in the major forest area, Central North Island (CNI). The national collectable forest residues range from 0.6 to 2.5 million odt p.a. (oven dry tonne) which will reach their peak in the period of 2023 to 2027. CNI stands out to be the most abundant area for the forest residues, supplying 0.3 to 0.7 million odt p.a. which accounts for approximately 40% of the national supply on average.

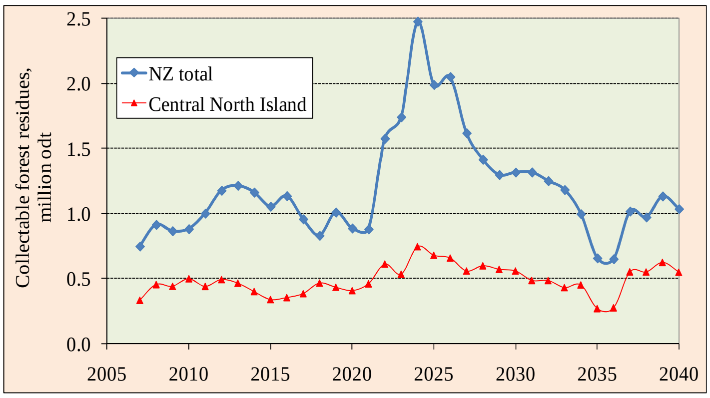

Fig.4. Collectable forest harvesting residues in NZ

2.2. Available wood processing residues

Wood processing residues are estimated based on the proportion of processing residues and the log processed in NZ. The wood processing residues include bark, sawdust, off cuts, shavings, log cores in veneer based wood products, veneer breakages, sander dust, trim offs and black liquor. Some good quality chips from sawmill offcuts are sold for pulp mills and medium density fibreboard (MDF) manufactures. Most of the wood processing residues have been used on site by the processing plants to fully or partially meet their heat and electricity demand. In some cases like MDF plants, wood processing residues are purchased to supplement its energy supply. The estimation and prediction of available wood processing residues are illustrated in Fig. 5. The national available wood processing residues are fairly stable at around 0.6-0.7 million odt p.a. from 2006 to 2021, reaching to a peak value of 1.3-1.7 million odt p.a. in 2023-2027 before deceasing in the following years. Similarly to the supply of forest residues, CNI has the most of the available wood processing residues, accounting for 57% of the national total on average. They are at around 0.5 million odt p.a. with the peak value of 0.7 million odt p.a. in 2024. With the significant amount of forest and processing residues, CNI is considered to be a suitable area for plants of bioenergy or biomass to liquid fuels.

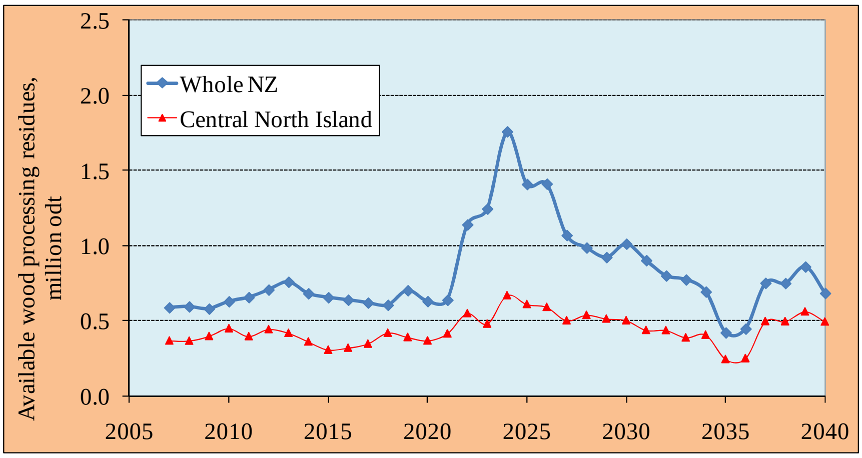

Fig.5. Available wood processing residues in NZ

2.3. Available agricultural residues

Residues from agricultural sector were estimated from production of three primary grains in New Zealand including wheat, barley and maize using Harvest Index. Residues from the grain production are estimated based on mass ratio (1:1) of residues to grains harvested. The available residues for collection are half of the total residues with 50% left on field for soil nutrients.

The production of wheat, barley and maize in New Zealand and in Canterbury area are estimated to be fairly constant from 2010 at about 0.84 and 0.54 odt p.a., respectively. The collectable agricultural crop residues are shown in Fig.6. Canterbury produces 64% of the national residues at around 0.27 million odt p.a., which is considered to be the only region that has sufficient agricultural residues to supplement a thermal chemical conversion plant.

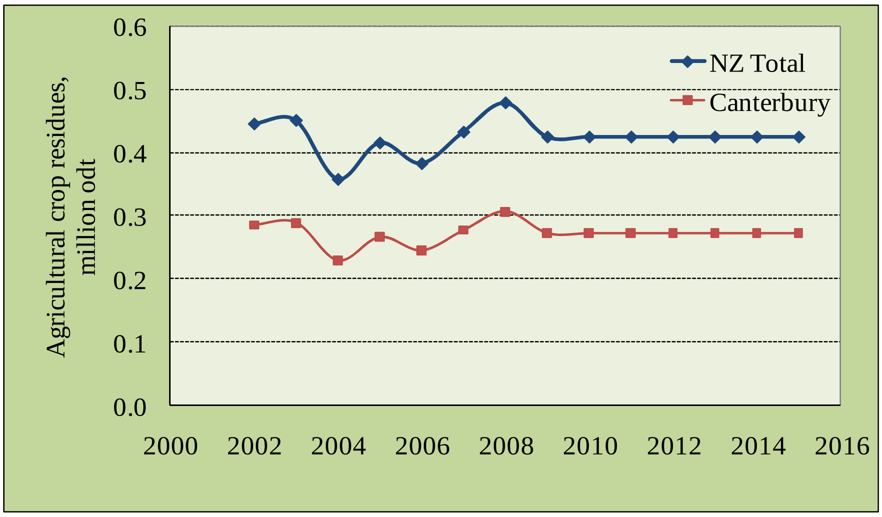

Fig.6. Available agricultural residues in NZ

3. Research & Development Institutes

University of Canterbury (UOC) in Christchurch and CRL Energy Ltd in Lower Hutt are the only two institutes in New Zealand to conduct research and development on thermal gasification. UOC is focusing on biomass gasification and collaborating with CRL for co-gasification of biomass and coal.

3.1. University of Canterbury

The author of this country report has established and been leading biomass gasification projects since 2004 in the Department of Chemical and Process Engineering (CAPE). A 100 kW (biomass in) dual fluidised bed (DFB) gasifier has been designed, constructed, commissioned and improved in the past 7 years. Fig.7 shows a photo of the gasifier with controlling system. The concept of the DFB gasifier was similar to the Güssing gasifier and the gasifier developed at Vienna University of Technology (VUT). Collaboration has been established between UoC and VUT. Modification of the gasifier has been conducted for testing of New Zealand feedstocks.

Fig. 7. 100 kW biomass gasifier in CAPE of UoC

3.1.1. BTSL research programme

The current research programme conducted at the University of Canterbury is Biomass to Syngas and Liquid Fuel (BTSL) (Pang 2011). The programme is funded by the Ministry of Business, Innovation and Employment (MBIE) for six years from 2008 to 2014. The programme is to adapt and develop the most advanced thermo-chemical conversion technologies to suit the NZ biomass resources. These technologies include using gasification to convert biomass into hydrogen-rich syngas followed by Fischer-Tropsch (F-T) synthesis to produce biodiesel for transport.

To suit the widely distributed and low density biomass, three options for syngas production are under development including gasification of entire biomass, co-gasification of biomass with coal, and densification of biomass by pyrolysis for gasification. The latter two processing routes will supplement the low energy content biomass which would otherwise cost too much in transport and storage on a commercial scale plant. In addition, the programme develops new biomass resources of herbaceous species and short rotation crops. An integrated model is being established to conduct feasibility studies from biomass to F-T biodiesel.

The programme is in collaboration with two research organisations (CRL Energy Ltd., and Plant and Food Research Ltd.) and supported by industry partners. An advisory Board has been established comprising invited bioenergy experts, representatives from the research collaborators and industry partners to oversee the overall research direction. A research team in CAPE at the UoC consists of five academic staff, three research associates, and eight postgraduate students with support from a number of technicians.

3.1.2. Achievements

Various feedstocks have been tested on the CAPE gasifier including:

- Wood pellets.
- Blends of wood pellets and biosolids or dried sewage.
- Blends of biomass and coal.

Modelling of gasification of biomass, and blended biomass and coal:

- Modelling of steam gasification of single chars.
- Modelling of gasification of biomass, and blended biomass and coal.
- The models can predict gas composition, gasification reaction rate and temperature profiles.
- The models have been validated and are being used for parameter sensitivity analysis.

Structure of the DFB gasifier has been modified for longer running time with the followings.

- A straight extension on siphon return leg to reduce sand losses by bypassing.
- Cyclone particle trap extension on producer gas cyclone to allow emptying of the ash trap on the run.
- In-bed feed system instead of over-bed.
- Sand recharging lock hopper for topping up bed material on the run.

A new control system was installed with data logging, gasifier monitoring and operation control.

Operation of the DFB gasifier has been optimised for right ratio of H_2 to CO in FT fuel synthesis, high C conversion efficiency and low tar content. Optimisation was conducted to investigate the effects of the following parameters:

- Steam/biomass ratio.
- Gasification temperature.
- Catalytic bed materials including olivine, dolomite, magnetite and calcite.
- Gas contact time or BFB bed height.

Flexibility of the DFB gasifier has been demonstrated in producing producer gases with a wide range ratio of H_2 to CO from 0.9 to 4.4. This means that the DFB gasifier we developed can be used for generation of energy using the producer gas of low ratio of H_2 to CO, for generation of Fischer-Tropsch syngas using the optimum H_2 to CO ratio of 2, or for hydrogen production using the high ratio of H_2 to CO.

To improve the gasification technology, fundamental studies are also carried out with mathematic modeling to simulate biomass gasification and co-gasification. A cold transparent gasification model as shown in Fig. 8 has been designed and constructed for study of flow hydrodynamics in the DFB gasifier and to develop design tools for scaling up of the DFB gasifier.

Fig. 8. Cold and transparent DFB model in UoC

A tar analysis method using GC-FID has been successfully developed to enable in-house and same day analysis. An internal standard calibration (with 5 different concentrations and 3 repeatable measurements) of 23 species has been conducted including 17 polycyclic aromatic hydrocarbons, 2 Heterocyclic compounds and 4 Aromatic compounds.

Gas cleaning technology is also under development, using integrated scrubber and stripper columns. Canola derived biodiesel is used as solvent in the system so that the tars in the producer gas are firstly absorbed in the scrubber and then the tars in the loaded biodiesel is released in the stripper to hot air. The hot air with tar can be sent to the combustion column of the gasifier for recovery of the tar energy.

3.2. CRL Energy Ltd

CRL Energy Ltd. is a coal research institute located in Lower Hutt, Wellington. They have constructed a 200 kW_{in} fluidized bed (FB) gasifier for research on lignite gasification to produce hydrogen since 2004. A gas clean-up line has been installed including a water-gas shift reactor, a Palladium membrane and a high temperature and high pressure gas separation unit to get pure hydrogen gas for fuel cell. The gasifier is now also used for co-gasification of coal and biomass. Experiments have been conducted to investigate the effects of the ratio of biomass to coal and gasification agents of air and oxygen. It was found that it is critical to prepare a uniform blend of biomass and coal for feeding to the gasifier. A method has been developed to making coal-biomass blend pellets (Levi 2011).

Currently, a 50 kW O_2 blown FB gasifier is in construction which is integrated with water electrolysis. The system is shown in Fig.9. It is planned to conduct co-gasification of up to 45% biomass with coal (Levi 2011).

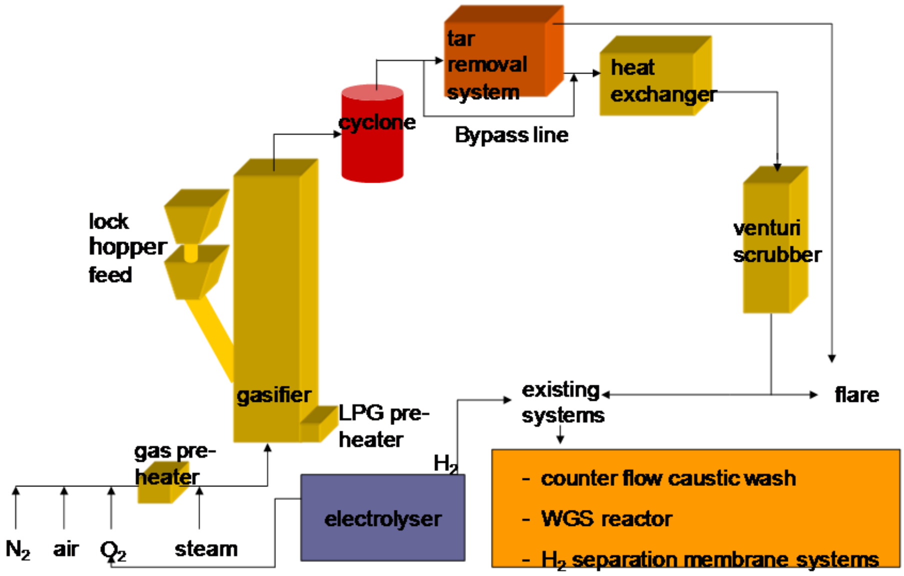

Fig.9. O_2 blown FB gasification system in CRL

4. Demonstration and Commercialisation

4.1. Waiariki wood waste gasification plant

A 1.5MW Agder Biocom (Norway) gasifier has just been built and in commissioning at Waiariki Institute of Technology (WIT), Rotorua, New Zealand. This project is jointly funded by New Zealand government (EECA), Windsor ™ Engineering Group Ltd (turn-key project) and WIT (owner). The gasification plant is served with the following functions:

- As a training facility for wood processing students at the WIT.
- As a R&D test facility to introduce gasifier technology to the wood processing industry in NZ.

- To replace the use of natural gas for the existing boiler to generate steam for two Windsor timber drying kilns of 20 and 30 m³ timber capacity.

The gasifier shown in Fig.10 is characterised as:

- Updraft type
- Thermal output 1.2 MW with 78% net efficiency using wood fuel with MC of up to 35%.
- Fuels: mixed shavings, hogging, sawdust and bark.
- Particulate emissions not greater than 50mg/Nm³.

Fig.10. Working principle of the Waiariki gasifier

4.2. Fluidyne Gasification

Fluidyne Gasification Ltd. in Auckland is active overseas to develop and commercialize its downdraft gasification process (100kWe-2MWe). The managing director, Doug Williams works in retirement with commercial groups wishing to implement gasification, and selected student mentoring assisting research into biomass carbons. A number of projects have been undertaken overseas including (Williams 2011):

- 100kWe Andes Class gasifier development programme in California, to replace the use of LPG to heat the CalForests Forestry Tree Nursery.
- Gasifiers with larger gas outputs equivalent to 250-500 kWe are to be built with a change of design concept containing the oxidizing bed parameters by 2013-15.
- West Biofuels in Woodland, California.
- The technology is currently licensed for sale in Australia through Flow Force Technologies
- Biocharcoal utilisation:
  - in potting mix for seedling trees.
  - activated carbon.

4.3. Potential opportunity

A potential commercial opportunity has just been raised to treat the demolished timber from the earthquake damaged buildings in Christchurch. Gasification of the timber is a promising way to utilise the waste for generation of heat or CHP for the inner city. It is in process to establish a collaboration between the UoC and the Christchurch City Council.

4.4. Page Macrae gasifier

Page Macrae Engineering Ltd. has shut down its 2MWth updraft gasification plant for two years as the user, CHH plywood mill, was closed down in Taronga, New Zealand.

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