Bioenergy Association of New Zealand

Occasional Paper 20

Renewable Energy Options for Christchurch's Rebuild

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1. Introduction

This occasional paper is based on the master's thesis of Simon Love, also published through BANZ, and entitled "Bioenergy Utilisation Opportunities in Christchurch & Recommendations from European Experiences". This shortened version provides a very brief outline of the bioenergy (and other renewable energy) options available to Christchurch for large-scale energy uses, such as a district energy scheme (DES), or in large commercial or industrial boilers.

This paper explains the main thesis findings in terms of available quantities, utilisation costs, and practicalities of developing each source in the region. Finally, the recommendations from the main report are outlined, to give experts, decision-makers and the public an overview of what can be done to encourage incorporation of renewable energy in Christchurch's future. To find more background information, literature review results, characterisation of the region, and references, please refer to the full thesis.

2. Background

This research was intended to provide aid to those making decisions related to Christchurch's rebuild, especially in regards to the proposed DES. A need was identified in earlier feasibility reports for further quantification and research into bioenergy supply chains in the region. This research was designed to fulfil that need, and provide a broader context to renewable energy in the Canterbury region.

The information below is the result of seven months' research, including interviews with over 35 experts directly involved with renewable energy in New Zealand and in Europe. The thesis research was based at the University of Graz in Austria, supervised by Professor Michael Narodoslawsky at the Technical University of Graz.

3. Which renewable energy sources are available?

Christchurch and the Canterbury plains contain a range of bioenergy and other renewable energy sources available for use. Many practical issues must be taken into account when assessing quantities of these resources – ease of collection, existing infrastructure, existing demand, distance from the city centre, and processing and storage requirements, to name a few. The available resources have been quantified and assessed using a combination of primary data from interviews, literature, previous assessments and existing databases.

The main bioenergy feedstocks available to Christchurch are wheat and barley straw, wood, gas from landfills and the wastewater treatment plant (WWTP), biogas from piggeries and other industrial processors, and dried sewage biosolids. Some seemingly-obvious energy sources are not readily usable in Canterbury – for example, biogas from dairy cows is not a feasible option due to manure collection difficulty associated with the extensive (i.e. pasture-based) nature of dairy farming in New Zealand. Biofuels from purpose-grown crops or waste cooking oil are, at this stage, too expensive to used on large scales; they may however be an option for backup and peak-use boilers. The largest source of landfill gas is at the Kate Valley landfill, approximately 60 km North of Christchurch; this distance makes delivery difficult. The most abundant and available bioenergy sources are shown in Table 1.

Table 1: Bioenergy Sources in Canterbury

Source	Estimate of Available Resource (GJ/yr)
Straw	4,500,000
Landfill and Wastewater Treatment Gas	550,000
Wood	500,000
Dried Sewage Biosolids	61,000
Piggery Biogas	52,000

As mentioned earlier, straw and wood are two of the most abundant fuels in the area; the location and intensity of these resources can be seen in Figure 1. Arable cropland is much more common than forest land, yet both wood and straw exist in usable quantities. What is clear from the images is that these resources often require significant (25 – 100 km) transportation distances to reach the city. Transportation and city delivery also comes with issues such as noise and dust, which can be minimised with forethought and planning.

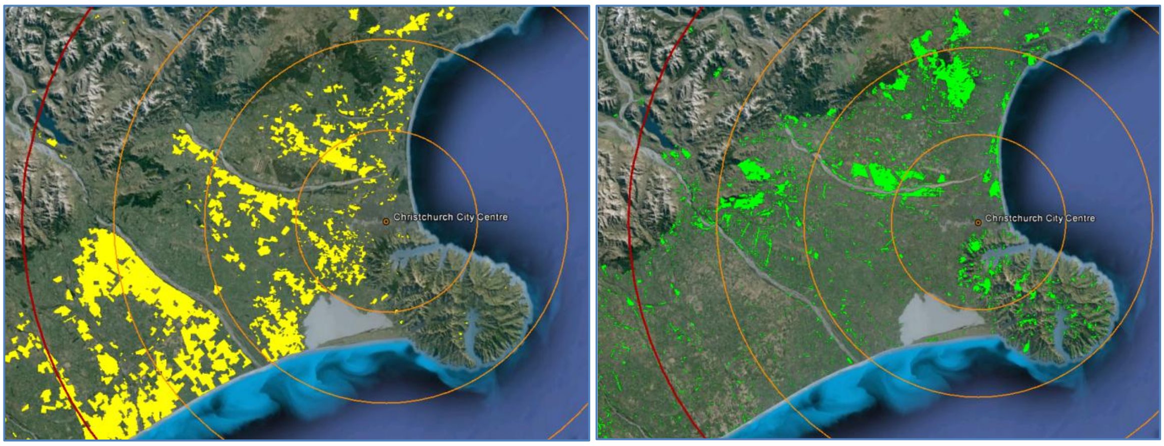

Figure 1: Arable cropland (left) and plantation forest (right) in the area around Christchurch. Each range ring represents 25 km. Source: New Zealand Land Cover Database and Google Earth

Other renewable sources available to the region are in the form of solar energy and waste heat within the city. Finally, heat pumps (ground source, air source or aquifer) can be used to provide heat using electricity.

The amount of solar radiation Christchurch receives each year is higher than many European countries, and is similar to Southern parts of France. This resource is underutilised in the city, and solar thermal systems could contribute to heating systems and hot water systems on a range of scales, including up to the district scale, as is done already for example in Austria.

Waste heat in the city is generally of low temperature, and should be utilised in close proximity to where it is generated. This research uncovered some usable sources of waste heat in the city, most notably at the Ravensdown Fertiliser plant in Hornby. Other sources include data centres, large chillers and other industrial plants – this requires further investigation. Also existing throughout the city are unused or underused boilers, which could be of use in creating cost-effective district heating or shared heating in the future.

For heat pumps to be used at large scales, a large source of low-value heat is required. In some parts of the world, lakes and/or the ocean are used. In Christchurch the aquifer underneath the city is likely the most constant source of heat during the winter. This is potentially a very effective way of producing heat in the city with minimum noise, emissions and disruption, yet needs more modelling and earthquake assessment before it can be recommended. Additionally, a heat pump system could potentially be run backwards in summer, to cool buildings, as well as store heat in the aquifer for use in the colder months. Heat storage in aquifers, tanks or the ground is an option that could be used with the other heat sources described above, particularly solar; this is described further in the main report.

4. How much would it cost?

Costs for bioenergy in Christchurch are difficult to estimate, especially when supply chains are relatively underdeveloped. The costs shown in Table 2 are calculated based on large-scale use, which would involve setting up new supply chains and contracts, transportation and logistics, and building infrastructure such as pelletising facilities. Also taken into account in these calculations are practical points such as the strong existing demand and competition for wood fuels, and the strong dependence on economies of scale for biogas. Due to the non-existence of a current market, straw prices are based on compensation for soil nutrient loss plus collection, baling, pelletisation and transportation costs.

Table 2: Costs of delivered fuel types in to Christchurch city

Fuel	$/GJ
Wood Chips	5.92
Wood Pellets	10.36
Straw	5.50
Straw Pellets	9.82
Biogas from Piggery & Industrial Waste	5.07 – 11.93
Landfill Gas (Burwood)	8.59
Landfill Gas (Kate Valley)1	10.19

Costs for delivered energy were also calculated, for both combined heat and power (CHP) and heat-only plants, including capital costs, operational and maintenance costs, and fuel costs (Table 3). Wood and straw plants were assumed to be large (20 to 50 MW) plants, while the other energy sources were assumed to be used in plants matching the size of the resource. These costs assumed a 10-year payback time, and a running time of 8,000 hours per year. This effectively means a full time energy supply in all seasons; this is realistic only if a use for the heat can be found in summer, for example industrial process heat, or hot water heating. As operational hours per year decrease, costs rise – for example, in cost calculations for scenarios of 4,000 hours per year, costs were typically 50% higher.

[1] The DES Technical study gives a figure for Kate Valley only, while this report gives a combined figure for Burwood, Kate Valley and the extra gas from the Bromley WWTP.

Table 3: Costs of delivered energy in Christchurch

Fuel	$/GJ Delivered Energy CHP @ 8,000 h/yr	$/GJ Delivered Energy Heat @ 8,000 h/yr
Wood Chips	13.43	10.69
Wood Pellets	15.54	12.80
Straw	16.23	9.56
Straw Pellets	17.27	13.20
Biogas from Piggery & Industrial Waste	15.96	-
Landfill Gas (Burwood)	19.35	9.73
Landfill Gas (Kate Valley)	20.95	11.33

These costs are conservative estimates, which nonetheless have a high margin of error, due to the fact that supply chains for most of these fuel sources are not well established. These prices are intended to give a 'ballpark' figure for feasibility purposes.

5. Why hasn't it been done before?

The question can be raised, especially when discussing straw – if the fuel source is abundant and competitively-priced, why hasn't a supply chain been set up before? The simple answer to this question comes down to two factors: costs and risks. Costs mainly arise in the form of capital costs for energy plants, and logistics/transportation. Wood, straw and manure, by nature, are not accumulated at a single point like fossil fuels. Therefore setting up a supply chain involves transport of smaller quantities from many different points, sometimes from up to 100 km away, which decreases efficiency, drives up costs, and increases environmental impacts. Low-value forest residues are difficult to collect, compared with the high-value logs, and straw must be stored and transported as necessary, due to its low density. Capital costs arise in the form of boilers which are often more complex than coal or diesel boilers. Capital costs can also include scrubbers, compressors and pipelines for landfill gas and biogas, balers for straw and pelletising plants for straw and wood.

Risk is the other factor holding back development. Straw removal for energy is a departure from traditional uses for straw; it requires compensation for nutrient removal from the land, finding an alternative straw burning for disease control, risks of price fluctuations based on supply variation, and potentially storing the straw on-site for long periods of time. Unfortunately, with fuels such as straw, a 'chicken and egg' situation has arisen, where energy producers do not want to risk investing in a boiler without a secure supply chain, and straw producers do not want to commit to straw baling, collection and storage without a guaranteed consumer.

External factors have an effect also. The economics of district heating are a challenge due to New Zealand's lightweight timber housing, low density neighbourhoods and mild climate compared with Europe. The central city is anticipated to have more high-density housing, which would provide a solid economic basis for a DES, yet this requires comprehensive planning and a close relationship between the city council and building owners to ensure enough customers are on board.

Add to the equation low coal prices, a lack of political will to increase renewable energy, and a depressed emissions trading scheme, and renewable fuels struggle to compete economically with coal. An extra issue in Christchurch is the perception of biomass combustion being dirty. Great strides have been made in boiler technology in recent decades, which has resulted in incredibly efficient, low-maintenance and clean biomass boiler systems – awareness of these systems needs improvement in New Zealand.

Despite these challenges, bioenergy technologies in Europe have developed steadily. Straw is used on very large scales for electricity and heat in Denmark and the UK. Forest residues in Sweden are being gasified to produce clean biogas to feed into the gas grid, and the UK's largest power plan (Drax) is beginning to switch entirely from coal to wood pellets. Austria has over 1500 wood-fired district heating plants. In other words, the technological basis already exists – it is just the supply chains that need to be developed in New Zealand.

6. How can we get things started?

One of the findings to come out of this research was the startling fact that many building owners, as well as the general public, are completely unaware that a DES is an option for the inner city. This raises the question that if no one knows it is an option, who will demand it and support it? It is clear that the decision-making process surrounding the DES requires more publicity and more transparency, to pique the interest of stakeholders and make it a point of discussion in Christchurch. Transparency is also required in the discussions around Kate Valley landfill's more than 10 MW of landfill gas, which is currently being flared. The best use for this may be a local heat user or conversion to vehicle fuel, however flaring such a large resource seems a wasted opportunity.

In terms of practical steps towards renewable energy implementation, one recommendation is the creation of a waste heat and spare boiler capacity database for the city. This research identified two usable sources of waste heat, and over 20 MW of spare boiler capacity; anecdotal evidence implies there is more in to be found the city. Knowledge of these sources could assist with design of a DES, or at the very least begin a conversation about using waste heat and unused or underused boilers in a more effective manner. An example is the cooling towers of Ravensdown in Hornby – a constant 6.5 MW of heat is unused, despite being situated close to potential large retail users.

Another practical step is for discussions to be facilitated between straw producers and Fonterra and Synlait. Both companies have large coal boilers located close to large quantities of straw. Straw pellets can be co-fired in coal boilers with very little boiler modification, and offer a local, renewable source of energy. This step would be an ideal way to kick-start the straw energy supply chain in Canterbury. Federated Farmers, the Foundation for Arable Research, or the Canterbury Regional Council could facilitate talks and begin feasibility studies.

It is clear that New Zealand's biofuel markets and supply chains need rapid development. Some excellent steps have been taken already, such as the development of EECA's good practice guidelines and the BANZ wood fuel classification guidelines. Still, wood and straw are not generally seen as modern, advanced fuels. Further adoption of the current guidelines must be encouraged, as well as developing current firewood and pellet retailers into ‘Biomass Logistic & Trade Centres’, which offer standardised, high-quality fuels to be used in modern energy systems.

Finally, ways to reduce capital cost risks around bioenergy sources must be investigated. It is clear that the New Zealand government does not have the resources to offer large subsidies as is the case in Europe. However, low-interest or guaranteed government loans, or other similar methods of financing and risk reduction could offer a way to stimulate investment in bioenergy. This is an ideal topic for further research.

As for other renewable energy technologies such as solar thermal panels, aquifer and ground-source heat pumps, and seasonal thermal storage, progress is taking the form of research, discussions between experts and the city council and submission of tenders. A ‘systems’ view needs to be taken by those planning the future of Christchurch – it is likely that energy will come from multiple systems using multiple energy sources, working together.

7. Conclusions

Since of the tragedy of the Christchurch earthquakes, many ideas have been put forward for what the city should look like in the future. These ideas have, to a large extent, focused on general points, rather than specifics. The feasibility studies for the DES brought a practical and specific proposal to the fore, and an expression of interest for the DES was released in July 2013, coinciding with the conclusion of this research.

There are many opportunities for bioenergy use in Christchurch, whether it is in the central city or in surrounding areas. This research offers stakeholders, including Christchurch City Holdings Limited (CCHL) as the decision maker for the DES, assistance in decision-making by providing quantity and cost estimates for use of these energy sources. The onus is now on the decision-makers to use this information as best they can.

Bioenergy may not be a complete solution for energy in the central city, and may not solve all needs at once. Likewise, a DES may not be the most efficient way of heating inner-city buildings. At the minimum, however, energy in the city should be a focus of debate, and now is the time to look for reliable, cost-effective and sustainable energy sources for the city. If Christchurch wants a modern, liveable city centre, and to spearhead a local economy based on renewable resources, then bioenergy and other renewable energy sources need to be seriously considered right now. Transparency, communication and openness to new ideas and technologies could go a long way in bringing a renewable energy focus to Christchurch.