Biomass heating for a commercial glasshouse / nursery

Zealandia Horticulture Ltd, Christchurch, New Zealand

Extended Case Study 8

ABSTRACT

An examination of the deployment of two medium scale biomass boilers to heat a large Horticulture facility, and the benefits delivered.

CONTENTS

1. BACKGROUND

Zealandia Horticulture is a large family-owned company that operate five production centres in total, three in Christchurch and two in Auckland. As well as supplying young plants for the food industry, they also supply the public with plants and flowers through more than 300 outlets all over New Zealand. If you have bought flowers for your garden, the chances are high that it was grown by Zealandia!

Zealandia have a strong environmental and sustainability ethos, believing in '*pro-active improvement of environmental performance*'. This means they don't just talk-the-talk, but they actually walk it too. They have invested heavily in state-of-the-art wood boilers to provide heat to the glasshouses at their largest two production centres. So your garden plant may even have enjoyed its early days thriving in an environmentally friendly bio-heat environment.

Glasshouses, particularly in the climate found in the South Island of New Zealand, require substantial amounts of heating to keep the air temperature within the desired temperature range of the crop. The heat is normally supplied from a centralised boiler house via hot water pipes. At Zealandia's Christchurch site the heat is distributed inside the glasshouse through under-floor heating as well as via height-adjustable over-head pipes, moved up and down to best match the crop height and heat requirement.

A large hot water 'buffer' tank is often placed between the boiler and the glasshouse, allowing more energy to be stored so that peak heat loads can be met with a smaller boiler, and to give greater control. In food-growing operations a large buffer tank also allows natural gas boilers to run during the day, even when heat is not needed. This enables the CO_2 produced as a by-product of gas combustion to be used to enrich the growing environment during the day (to increase crop yield), and enables the heat to be stored for use at night. However CO_2 enrichment is not needed, or desirable, when growing seedlings and flowers, so the purpose of this sites 1,000,000 litre tank is to allow more efficient boiler operation as well as providing a back-up. When fully loaded it stores about 43,500kWh of heat, enough to last 2-3 days.

This case study examines in detail the wood-based heating system at Zealandia's Belfast site in Christchurch. Certain information has been withheld to protect commercial interests.

2. THE BUSINESS CASE

a. Some history

Normally the significant new investment required to install a modern wood boiler is justified by a business case based around energy cost savings – but not in this case. Zealandia's Belfast site had actually been heated with wood energy for 8-9 years before a decision was taken to deploy the latest biomass combustion technology at the site. The hot water was produced by a Vekos boiler running on a dry wood chip sourced from old pallets and packaging waste. Although rated at 6MW when running on coal, it was producing around 3MW when running on wood chip. The Vekos was backed-up by a 1.5MW diesel boiler. So this project was not about realising major fuel cost savings.

Designed in the UK and manufactured in New Zealand by Scotts Engineering Co Ltd of Christchurch, Vekos boilers were primarily designed to burn coal, but the 'multi-fuel' versions are also capable of using wood fuels, although only if the moisture content is less than 25%, and ideally in the range of 10-20%. This Vekos was originally operating on coal at a meat factory in Marlborough.

Fig. 1: The Vekos boiler in place at Zealandia. This has now been sold.

The reason Vekos boilers need dry wood fuel is that a large combustion chamber and ample refractory is required in order to thoroughly and cleanly combust wood that typically has a significantly higher moisture than coal, in fact can be up to 60% water in some cases.

Compounding the water issue, the fact that wood fuel also has a significantly lower energy density than coal, measured in GJ per cubic metre, also represents a problem. Depending on the type of coal and the moisture content and bulk density of the particular wood fuel, coal can have over ten times the energy density of wood. Even the drier wood chip used in the Vekos has less than 20% of the energy of coal (<$4GJ_{gr}/m^3$ compared to coal at about $20GJ_{gr}/m^3$). This means that the fuel feed and fans of Zealandia's Vekos required upgrading to squeeze sufficient wood and air into the combustion chamber. Zealandia have skills in-house so did most of this themselves, under the expert guidance of Scotts Engineering.

b. So why switch ?

Unfortunately, as well as requiring a dry wood fuel, another downside of Vekos' wood-compromised design is that they emit high levels of unburnt fuels in the form of soot or 'particulates' from the chimney. Although it may appear to the naked eye that they burn cleanly – with sometimes no smoke visible – even with a multi-cyclone their emissions would typically be in the range of 300-800mg/Nm^3 of Total Suspended Particulates (TSP's). This site, though, kept the boiler particularly well-tuned, so TSP levels could be achieved of closer to 250mg. At some sites TSP levels over 1000mg/Nm^3 and approaching 2000mg/Nm^3 have been recorded. As well as occurring at start-up, these levels may also occur if the boiler is not well tuned and/or if slugs of wet fuel are delivered and/or the boiler is turned-down for extended periods, so cools.

To put this into context, the Canterbury Regional Council are requiring semi-rural sites such as this to emit below 230mg/Nm^3 of TSP's. Boilers in more built-up areas such as at Burwood and Hillmorton hospitals are required to emit less than 50mg/Nm^3. Modern wood boilers are able to achieve <230mg with just the use of a multi-cyclone, which are effective at capturing the larger particulates.

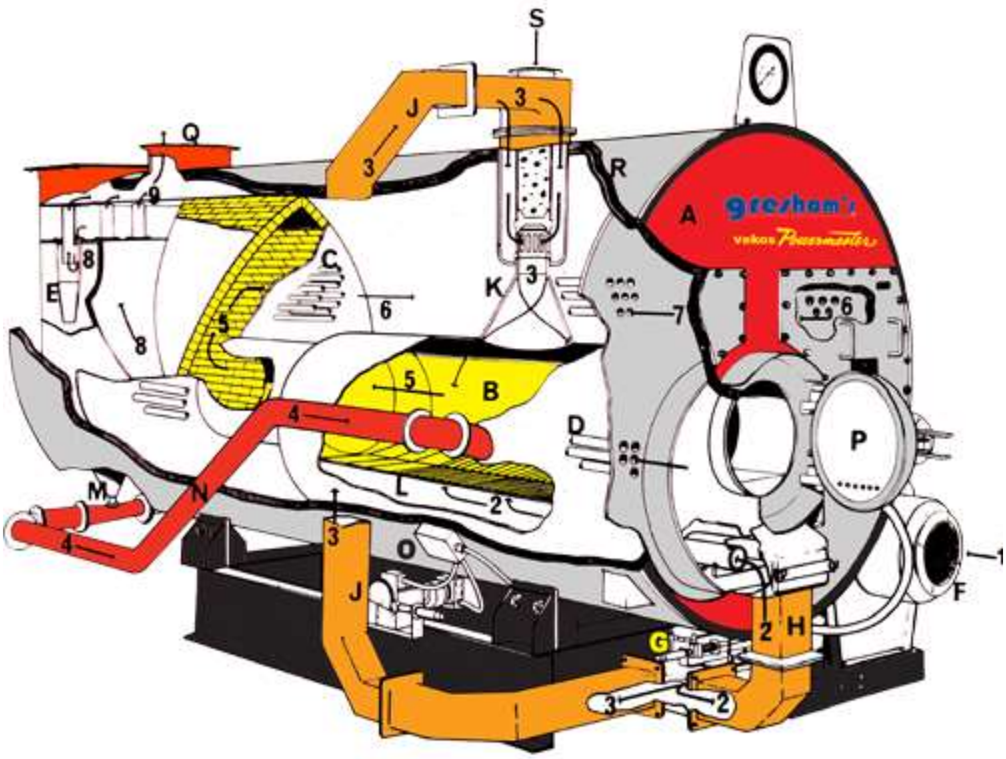

Fig. 2: Cut-away of a Vekos boiler, showing fuel in-feed at the top.

The reason for the relatively high particulate emissions from Vekos boilers when using wood is the different combustion characteristics of wood compared to coal. Coal combustion occurs on the grate or just above it, whereas the volatiles in wood are released as it is heated and pyrolised, and these are then combusted in suspension in an optimised air mix. Because of these characteristics, a combustion chamber designed primarily for coal will be smaller and have less air flow compared to a combustion chamber designed specifically to combust wood. To fully burn the volatiles, wood boilers need a different mix of under-fire air ('primary air') and over-fire ('secondary') air, as well as more turbulence and more air overall. See the contrasting boiler cut-away on page 10.

So, to burn wood, modifications to Vekos boilers needs to be performed, for instance boosting the fan sizes and air ducts, and altering the air distribution ratios into the combustion chamber. The actual combustion chamber design, however, will still be ill-suited to ensure all the volatiles are fully burnt-out, so the process is unavoidably compromised compared to a purpose-built wood combustion system.

The requirement for greater air turbulence (so higher air flow) in a sub-optimal chamber also inevitably entrains particles of wood fuel in the airflow, and these don't have sufficient time to be fully consumed in the more compact coal-oriented combustion chamber, leading to high emissions.

The higher particulate emissions from converted boilers was accepted for many decades. However now there is a greater understanding of the health dangers caused by high levels of particulates in the ambient air, in particular particles below 10 microns, hence emissions standards are tightening.

With tightening air quality regulations across New Zealand, Zealandia's Belfast site was given notice by the Regional Council that their current levels of particulate emissions would not be granted consent renewal. They would need to deliver TSP levels below 230mg/Nm^3. So the hunt began for the best solution

Fig. 3: The Polytechnik grate at Zealandia. Note the combustion of volatiles above the fuel.

c. What were the options ?

The easiest solution appeared to be to retro-fit a baghouse, which would capture a large percentage of the particulates from the boiler flue gas, ensuring the remaining particulates are below the permissible level. There were a few other ways to achieve compliance:

- Use other flue-gas clean-up equipment such as an Electro-Static Precipitator (ESP). Though this technology is widely available and cost effective, it was not considered as an option as there was no local provider promoting this solution at the time. ESP's have since been deployed at other wood boiler sites in the area (Hillmorton and Burwood Hospitals) as they offer various operational advantages such as lower power usage, near-zero fire-risk, no need to replace the bags etc. They also offer greater tolerance of flue gases with higher moisture content, so are better suited to wood boilers.

Fig. 4: A partially assembled ESP for the 1.5MW wood chip boiler at Hillmorton Hospital, Christchurch

- Generate hot water using the diesel boiler instead of the Vekos boiler. This option was quickly discounted as it would have led to an 800-1000% increase in heating costs. The owners are also strong advocates of renewable energy, so this option would not have been seriously contemplated even if cost competitive
- Install a taller chimney, or extend the current one, and perform dispersion modelling to show that the local air-shed would not breach its limits under the National Environmental Standards for Air Quality. This basically involves spreading the same volume of soot over a wider area, so was not considered as a sustainable environmental solution
- Install a purpose-built wood boiler that would achieve the required levels without a baghouse. Initially this was not seriously considered as it was not known that wood boilers could achieve the required levels without a baghouse.

So a decision to install a new baghouse on the back end of the Vekos (after the existing multi-cyclone) looked inevitable, and prices were sought for a new baghouse and ID fan from local manufacturers

d. A late change of direction

In 2013 K&L Nurseries, another glasshouse about 30 minutes to the South, had installed a 900kW wood boiler, supplied by Polytechnik Biomass Energy Ltd, the New Zealand branch of the Austrian wood boiler manufacturers. This boiler was starting to gain significant publicity in the area, and in fact went on to be crowned the Supreme Winner of EECA's annual energy awards in 2014.

Vince and his brothers Pedro and Paul, heard about the nearby project through their water treatment specialist, so went to have a look. Ian Kempthorne of K&L Nurseries says about his boiler "*Due to the large furnace and moving grate system it has good control on a wide range of fuel types. Flexibility is the key to it all and the sophisticated computer controls the boiler indicates this system has one of the best emissions of any boiler in the country*"

Fig. 5: The wood boiler at K&L Nurseries, 20 mins south of Christchurch

Vince Wylaars and his brothers Pedro and Paul, were impressed with the state-of-the-art wood boiler, operating fully automatically and, most importantly, burning cleanly. It easily complied with the emissions requirements without anything more than a multi-cyclone system – the standard minimum on such boilers. Multi-cyclones extract the largest particulates, and are simple, robust and low maintenance items – which cannot be said of baghouses.

Vince decided to travel to Europe to view various other Polytechnik boilers, and returned to New Zealand convinced this was the right technology for them.

e. The Business Case – why spend more than the minimum ?

Many businesses will take the approach of gaining compliance with minimum spend, as achievable by the baghouse solution. However the baghouse solution can be compared to the ambulance at the bottom of the cliff, and quite an expensive ambulance too, with high operating costs. The owners, having now seen that it was possible to put a fence at the top of the cliff, decided to go that route and replace their compromised combustion system with a new purpose-built 1.6MW Polytechnik wood boiler. That would avoid the expenditure on a new baghouse, but the extra cost of the overall project would still be substantial – so how was that rationalised?

There are several other factors that contributed to the Business Case:

Factor 1: Equipment Obsolescence

i) **Lifespan of the old boiler** The Vekos was already around 20 years old. Putting a baghouse on the back end would arguably be comparable to putting a new handle on a well-worn axe head. Inevitably, in the end, the axe-head itself would need replacing.

ii) **2nd hand value** Although the boiler was of a reasonable vintage, it still had a few years left in it, especially if only used for a couple of months per year. Zealandia were able to find just such a buyer for the equipment, a hop drying operation in Marlborough. The Vekos would be relatively-well suited to this application, as dry wood fuel will be available during the two months of hop drying, and it is easier to justify such a boiler when its shortfalls only need to be tolerated for 6-8 weeks per year. The value received was reasonable, and helped mitigate the capital cost of buying the new boiler.

iii) **Future Expansion** The Vekos was only permitted to be operated between 7am and 9pm. This had not been a problem as the 1000m^3 buffer tank could store energy for release during the night. Whilst only feeding 1.5ha of heated glasshouse, this arrangement was ample. But there were plans afoot to expand production over the coming years with significantly more heated glasshouse area. So in the future the Vekos and buffer tank would not be able to meet demand. Either a larger tank would be needed, or a boiler that would be permitted to operate 24x7.

Factor 2: Risk Management

i) Fire Risk Baghouses capture unburnt carbon very efficiently. When a stray spark makes it all the way into the bags, this carbon can, and sometimes does, ignite. This is a moderately regular occurrence at sites with baghouses. It requires significant remediation, as well as replacement bags, so involves an extended interruption to boiler operation, during which time expensive diesel would have to be used in this case. The replacement bags are also not cheap, in the range of $30-50k at this site, depending on specification, making a bag-fire a double whammy.

ii) Future Fuel Risk Changing wood fuel supply was not a key driver behind the decision, as Zealandia are very happy with their existing wood fuel supply arrangements. The fuel is of good quality, being hogged and screened end-of-life pallets, with all the nails removed via magnet. The fuel supplier is reliable and the price per GJ is good, in the range of $5-$10/GJ_{net}. However, it is prudent to plan for the unexpected in an ever-changing world. Events such as change of ownership, business continuity, earthquakes, fire, new technology (e.g. plastic pallets) or new competition for old pallets all represent threats to a permanent arrangement. The Vekos has a tight fuel specification, and if that fuel becomes unavailable for whatever reason, the site would be forced to procure fuel of a similar quality at the suppliers chosen rate. Investing in a more fuel-flexible wood boiler greatly reduces the fuel supply risk.

iii) Fuel Handling Risk Wood fuel was introduced to the Vekos boiler through an inlet on top of the combustion chamber, as shown in Fig. 2, and is just visible in Fig. 1. The wood was conveyed from the fuel store to the fuel inlet using pneumatic conveying – so entrained in an air flow inside a pipe, in this case in a 5" water pipe. It was decided that, given the new wood boiler would have a much wider fuel tolerance range, it needed a fuel delivery system that was sufficiently robust and flexible. So the effective-but-restrictive pneumatic conveying system would be replaced with a chain conveyor transfer system, feeding to a ram stoker. This is an intrinsically more robust system.

Factor 3: Operational Costs

i) Bag Replacements Even without a fire, the bags require regular replacements. Filtering the flue gases from wood fuel combustion reduces their expected lifespan even more so than coal. If the moisture-laden wood fuel gases cool past the dew point, say at shut-down or during turn-down, the moisture condenses and can combine with the previously captured carbon, to form a hard cake which cannot be easily removed. Even if this caking does not occur, the bags have a limited lifespan, so require replacement every 3-5 years, sometimes even more often.

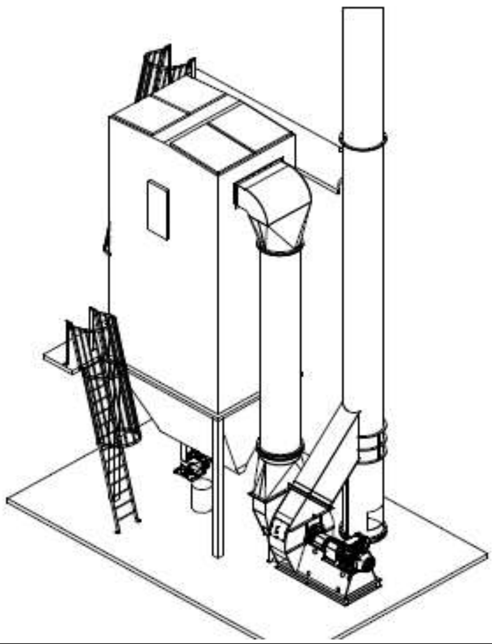

Fig. 6: Showing a typical baghouse and induced draught fan arrangement, this for a 5MW boiler.

ii) Electricity Usage On top of the bag replacement, because of the high pressure drop, baghouses require a large induced draught fan to suck the air through (shown bottom right in Image 6 above), which adds significantly to the boiler running costs

iii) Ease of Operation The owners had seen how modern wood boilers operate without any manual intervention. The Vekos needed regular tinkering and manual ash removal, representing man-hours that could be better deployed elsewhere with a less needy system

iv) Fuel Handling Costs Pneumatic conveying of wood fuel to a Vekos is common, but it requires significant amount of air flow, and this site had an 8kW fan running continuously during boiler operation. The wood fuel was dropped into this continuous air flow by an auger. The new chain conveyor would only activate when fuel is required, so a continuously running 8kW motor was able to be eliminated, with associated savings in operational costs.

Overall It can be see that the operational and running cost implications of installing a baghouse to filter flue gases from wood combustion are significant. Those factors may have been sufficient on their own. When the avoided cost of a baghouse was combined with the revenue received for the Vekos, it more than covered the ex-factory price of the new wood boiler. On top of this, there were other good reasons to invest, in particular the owner's desire to future-proof their operation, as well as their future expansion plans. There were other non-boiler costs involved, such as upgrading the fuel transfer system (see details in Section 3) and adding a fire-proof wall to the existing building.

However, having considered all the available technology solutions, they decided it was sufficiently compelling to invest more up front to get the best long-term solution.

f. Wood boiler sizing

With wood boilers, it is crucial to get the boiler sizing right. The over-sizing that is common and acceptable in other boiler types will have a disproportionately large negative impact on the capital, and on the efficiency therefore the operational cost, as well as on the longevity of a wood boiler. So Step One with any potential wood boiler project is to verify the correct wood boiler sizing, and only then should costings be sought for comparison purposes.

See the Extended Case Study 7 (Carrington College, University of Otago) for a more detailed discussion of this topic. On this project, Polytechnik, very experienced in these matters, could give appropriate advice regarding optimum boiler sizing.

g. Thinking long term

In fact, as well as investing in a 1.6MW Polytechnik, it was decided to simultaneously purchase a 2nd Polytechnik of 2.5MW at the same time. These sizes were calculated to match the heat demand after the planned future expansion(s).

The asymmetrical sizing means the smaller boiler would meet the summer heating duties, the large boiler would suit the shoulders of the seasons, and both boilers would run together in the winter. With a 20-25% turn-down capability, this gives an operational range from 350kW up to the full 4100kW.

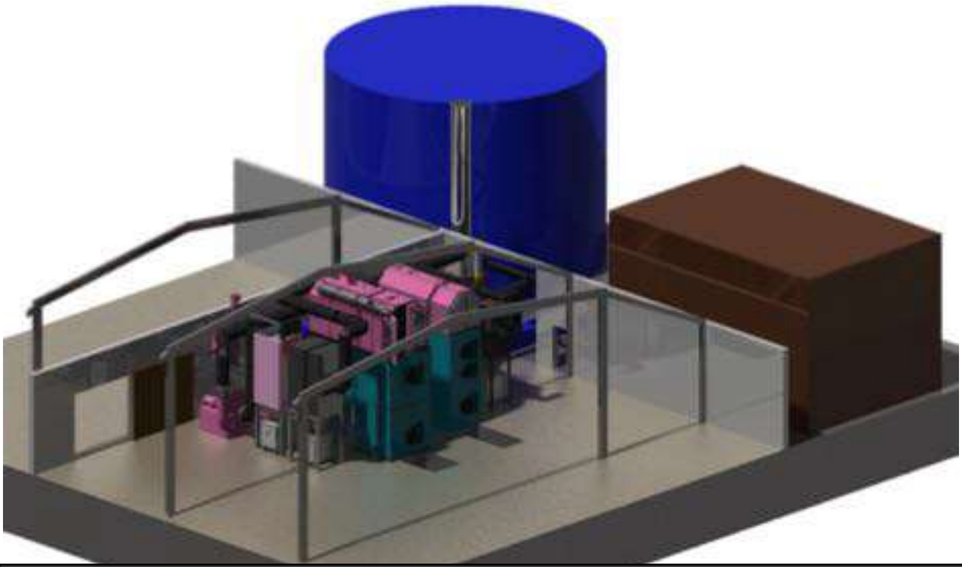

Fig. 7: Showing the overall arrangement of the 2 wood boilers, the buffer tank, and the fuel store

3. EQUIPMENT SPECIFICATION & CONFIGURATION

h. Wood chip boiler specification

The boilers installed were Polytechnik's 1600kW and 2500kW models, with just the 1600kW set to be commissioned until the glasshouse expansion was complete. The boilers have reciprocating grates to shuffle the fuel from the entry end to the ash extraction end (see cross-section below). The key technical features of the 1600kW boiler are as follows :

- Output range:	350kW to 1,600 kW
- Fuel specification:	Currently hogged pallets (around 15-20% m.c.) but designed for bark, sawdust, wood chips and hogged fuel up to 60% m.c.
- Weight:	45 tonnes (excluding air preheater & multi-clone)
- Efficiency at MCR:	87-93% depending on fuel & operating conditions
- Particulate emissions (full load):	Last test = 53 mg/Nm^3 at 12% CO_2 (after multi-clone)
- Water flow temperature:	Currently 94°C
- Buffer tank:	1,000,000 litres, providing 43,500 kWh when full

The Polytechnik boilers are very efficient and clean burning. The actual particulate emissions achieved in real life depend on the fuel and the operating conditions, so the 53mg/Nm^3 shown above is more meaningful than laboratory-based tests. These tend to show a best case outcome, and is not necessarily realistic under actual field conditions.

The low particulate emission levels are possible due to the high residence time, large amounts of refractory, carefully controlled air flows, multiple sensors and sophisticated controls. This schematic shows the cross section.

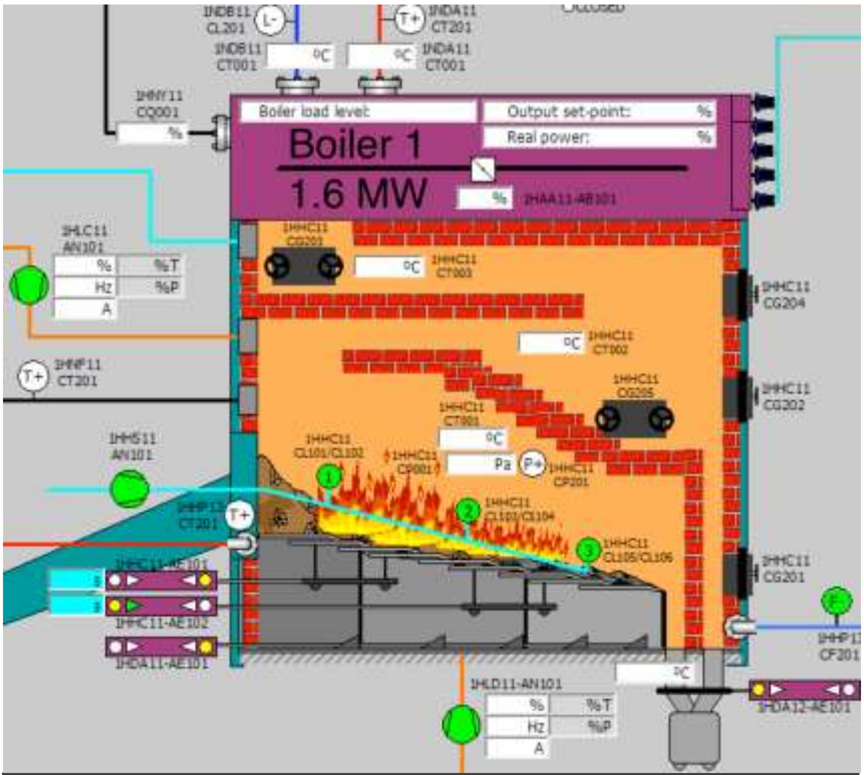

Fig. 8: Cross-section of the combustion chamber

The long route the flue gases travel can be seen. This ensures all particles and volatiles are consumed.

The screen-shot graphic below shows the components of the project, from fuel storage to fuel recovery, transfer, feed, combustion, ash removal, multi-cyclone, air pre-heater and flue.

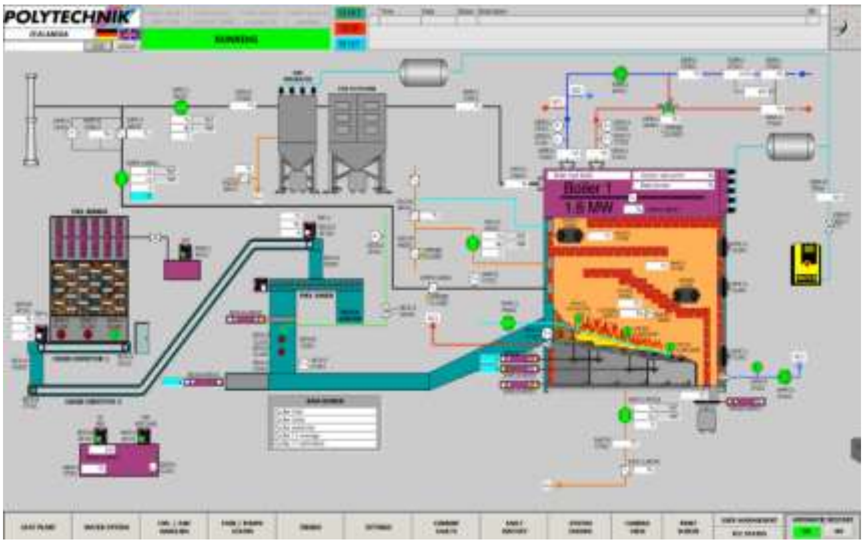

Fig. 9: Showing the overview screen of the graphics

Consistent with this genre of sophisticated boilers, the system comes with a detailed graphics package customised for the specific project.

See Extended Case Study 7 for a discussion of the features incorporated into modern wood boilers (e.g. modulating control to match the heat load, lambda control with exhaust gas recirculation, automatic tube cleaning etc). Suffice it to say that this boiler has all the sophisticated sensors and feed-back loops and safety features expected – and then some.

The two boilers are positioned side by side. There is good access via the extensive walk-ways.

Both boilers are fed from one fuel store with one fuel recovery and transfer system.
See section 5 for more detail on the fuel recovery and transfer system.

See Extended Case Study 6 and 7 for a detailed discussion of the other features that should be supplied with a modern wood boilers, such as:

- Burn-back control to prevent fire spreading back down the fuel feed system and potentially into the fuel store
- A system to prevent over-heating of the water in the event it ceasing to be circulated due to a pump outage (maybe because of power failure
- Back End Protection, a feature that maintains a minimum return temperature to the boiler, to prevent condensation on the heat exchange surfaces and potential corrosion. The appropriate minimum temperature depends upon the fuel moisture content, but, in any event, should not be less than 60°C

An optional extra, supplied with this boiler, is a camera view of the combustion chamber, with the live image available via a web-link to Polytechnik's combustion technicians, allowing them to better support from off-site.

Fig. 10: The 1.6MW and 2.5MW boilers. Note the compressed air nozzles to clean the boiler tubes

The real-time information on the status of the combustion is very useful when tuning the boiler from afar.

The hot water from the wood boilers can go either directly to the 1,000,000 litre accumulator tank (shown below right), or directly to the glasshouse via the network distribution header

The buffer tank can store 2-3 days of heat, meaning the 1.6MW boiler does not need a back-up boiler during this phase.

The 2.5MW boiler will be commissioned once the heat demand increases with the glasshouse expansion.

Fig. 11: The 1,000,000 litre insulated accumulator tank, able to store 43,500kWh of heat

The boiler control system sends a text to designated mobile phones should an alarm occur, allowing a timely response.

The PLC records key information over the last 24 hours, and shows these as 'trends'..

Other screens show the buffer tank status, the run hours or cycles per component, the fuel feed settings, the fan settings, the O_2 levels, the ash handling settings, the pump status etc

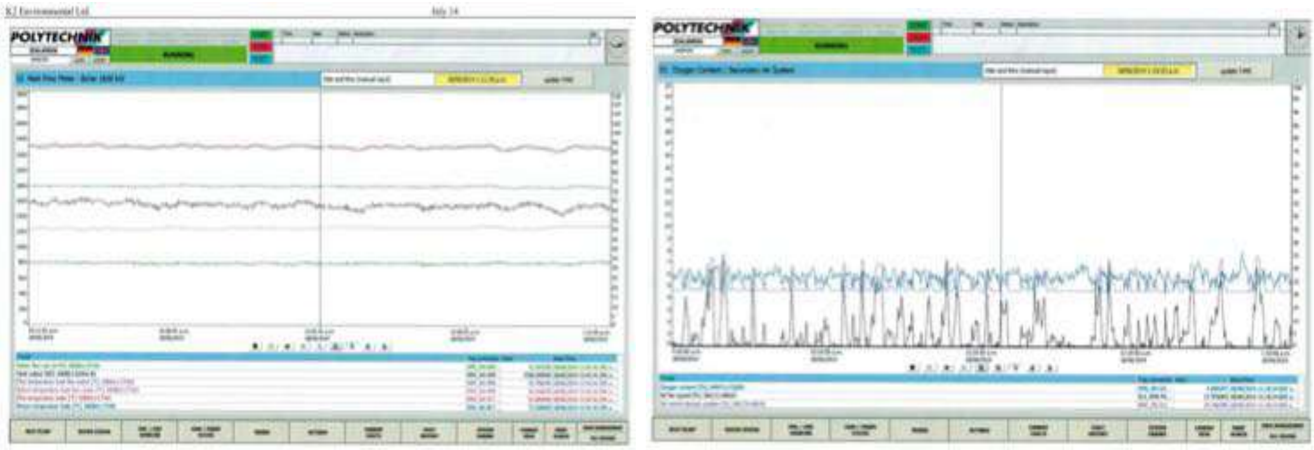

Fig. 12: Example of some of the trends available, graphing data over the requested time period

i. Wood fuel storage

The old fuel storage mechanism was retained, with a tilt-slab store able to hold about 300m^3 of wood fuel. Currently the truck discharges the wood fuel onto the fuel reception pad shown below left.

After discharge, the wood fuel is loaded into the fuel store (above right) using a telehandler. Inside the fuel store there are six reciprocating 'walking floors' which move the fuel to the left of the photo shown. The six push-floor hydraulic rams and power pack are located in the lean-to to the right.

See Section 5 for more detail on the fuel storage, transfer and feed system.

Figs. 13 & 14: The biomass reception area, and the fuel store.

4. SO WHAT ACTUALLY HAPPENED

a. Boiler operation

The Vekos was sold and removed, as was the old back-up 1.5MW diesel boiler. The owners decided to install both wood boilers at once, because an expansion of the glasshouse was anticipated to follow in the next year or so, and some synergies could be realised by installing both at once.

So both new biomass boilers were installed in late 2013 and early 2014, and the 1.6MW system was brought on-stream in April 2014, in conjunction with the existing buffer tank. Unfortunately the intended glasshouse expansion had to be considerably delayed, due to having to work through various issues with the Council related to earthquake/seismic loading. Those issues are now resolved, and the expansion is proceeding, with increased heat load expected by winter 2019. Shortly prior to then, the 2.5MW biomass boiler will be fully commissioned so that the boilers can operate in tandem as originally intended.

The screenshot below shows the trends over an eight day period in June 2015. The undulating top line is the heat stored in the buffer tank. The jagged red line is the heat demanded by the glasshouse. The jagged blue line is the heat output from the buffer tank, and it can be seen how this closely tracks to heat demand. The consistent black line is the boiler output.

The 1.6MW boiler is targeting to ensure that the buffer tank has sufficient energy to meet the demand, but it also factors in the expected drop-off in heat demand in the afternoon.

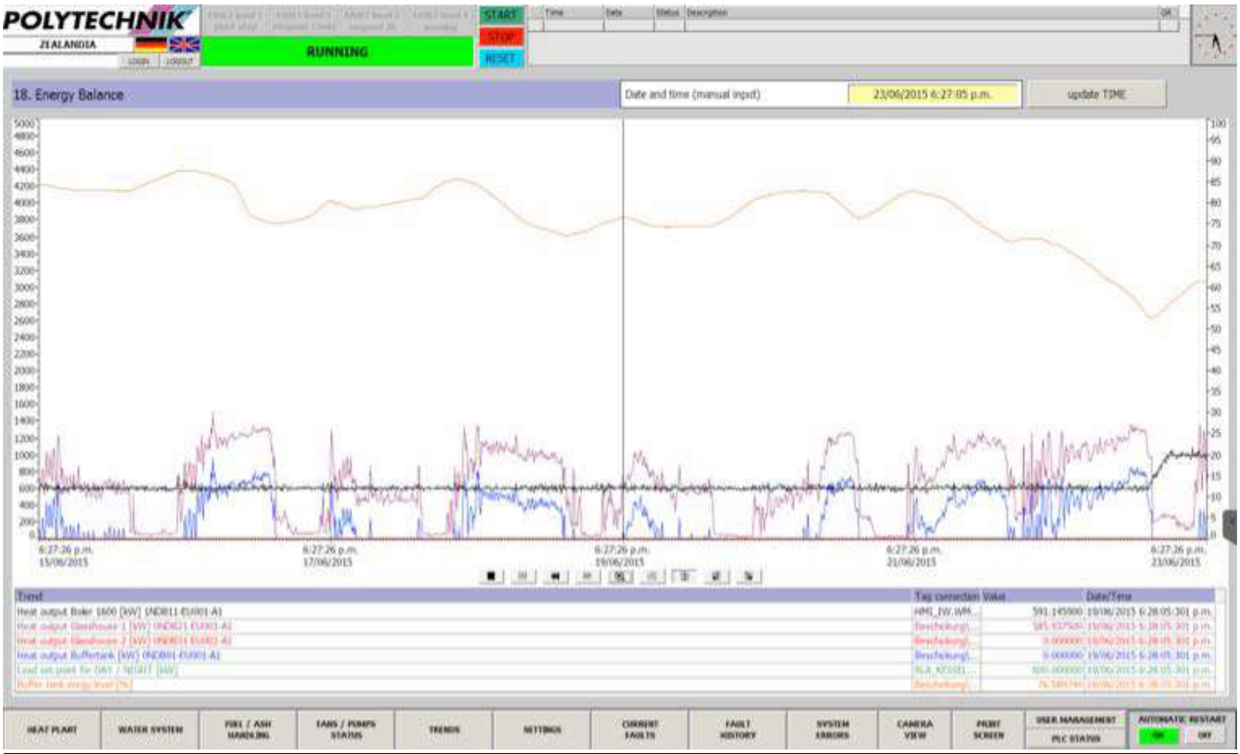

Fig. 15: Showing 8 days of trends

Some observations on the graph above :

- Clear daily trends can be observed, showing the heat demand growing in the early hours of the day
- The heat demanded from the buffer tank falls off quite steeply in the afternoons as the ambient air warms, and the sun rises in the sky so solar energy is able to meet the (now reduced) afternoon heat demand from the glasshouse
- When the glasshouse drains heat from the tank, the boiler does not increase its output in order to maintain the tank temperature. Instead it anticipates the afternoon fall in demand and knows that it can boost the tank temperature back to the required level by running at a continuous 600kW
- A cold-snap hits on Day 8 – see the significant rise in heat demand on Day 8
- This drains the buffer tank more than usual (see the top line), to the point where the boiler is triggered to raise its output, even though it is the afternoon and heat demand is now low
- As the boiler ramps up, the energy in the tank begins to climb again, back towards normal levels
- The boiler could ramp-up considerably higher, but only increases to the level required (1000kW in this case) to get the heat storage back to more normal levels, ready to meet the night's heat demand.

This pattern of operation allows the boiler to run at a continuous output, rather than ramping up and down unnecessarily, so it can operate in a manner that optimises efficiency, keeping the fuel feed, the fans speed, as well as the refractory temperature consistent.

b. Actual running costs

Different crops can require very different heating regimes. So the temperature in the glasshouse can be required to be anything between 3°C and 25°C depending on the crop and the time of year.

The purpose-built and sophisticated Polytechnik is considerably more efficient than the Vekos, combusting all the volatiles and airborne fuel thoroughly. So wood fuel usage could be expected to reduce by 10-20%, depending on how old the boiler was, how clean its tubes were kept, and how well it was tuned. Unfortunately immediately after the boiler change-over, the production increased, and the crop also changed. So there is no meaningful comparison showing the wood fuel usage before and after change-over.

Fig. 16: The dry wood fuel – hogged and screened pallets, with all nails removed.

Around 2000 tonnes of wood chip are used annually. This equates to roughly 15-18,000GJ/ha/year, which is in the upper-middle of the industry range. Energy screens are deployed to act as an insulator at night, to reduce the heat demand, but the local climate and the crop type mean it would be unrealistic to expect to achieve better than the national average.

c. Actual Emissions

The Emissions Consent required Total Suspended Particulates (TSP's) to be less than 230mg/Nm^3 at 12% CO_2. The Polytechnic duly delivered, with the first test showing an average of 53mg/Nm^3.

This was achieved with just a multi-cyclone to extract the larger particulates. So the boiler emitted around a quarter of the permitted particulate emissions, whereas the Vekos had been tested between September 2009 and April 2012 with results of 520, 1400, 500, 400, 315, 270 and 360mg.

These last four results reflect a well-tuned Vekos operating on a good quality dry wood chip.

5. RISK ANALYSIS

This project was an extremely low risk one. Normally, in instigating a biomass boiler project there may be some risks, or at least perceived risks. These can be related to different aspects of the project such as the boiler, the supplier, the wood fuel itself, or the fuel reception, fuel recovery and fuel transfer and stoker system. In this case, the project was specifically about minimising future risk.

See the Extended Case Studies 6 and 7 for a more detailed analysis of the kinds of risks (or perceived risks) that need to be managed. On this project, because the site was already using wood energy, the risks can be succinctly summarised as follows :

a. Boiler reliability risk

This project involved installing one of the most reliable wood boiler brands available. This delivers significant risk reduction compared to running the 'multi-fuel' Vekos (read 'coal, pellets and dry wood fuel').

Furthermore, the installation of a second Polytechnik wood boiler means that the expensive-to-run back-up diesel boiler was also able to be eliminated.

The graphic below shows the two wood boilers, and the buffer tank. It also shows the diesel burner, although that has now been removed.

The 1,000m^3 accumulator tank provides additional security, giving 2-3 days to solve any boiler-related problems. Once the heat demand has increased with the expansion, and second wood boiler is commissioned, the risk will be near zero.

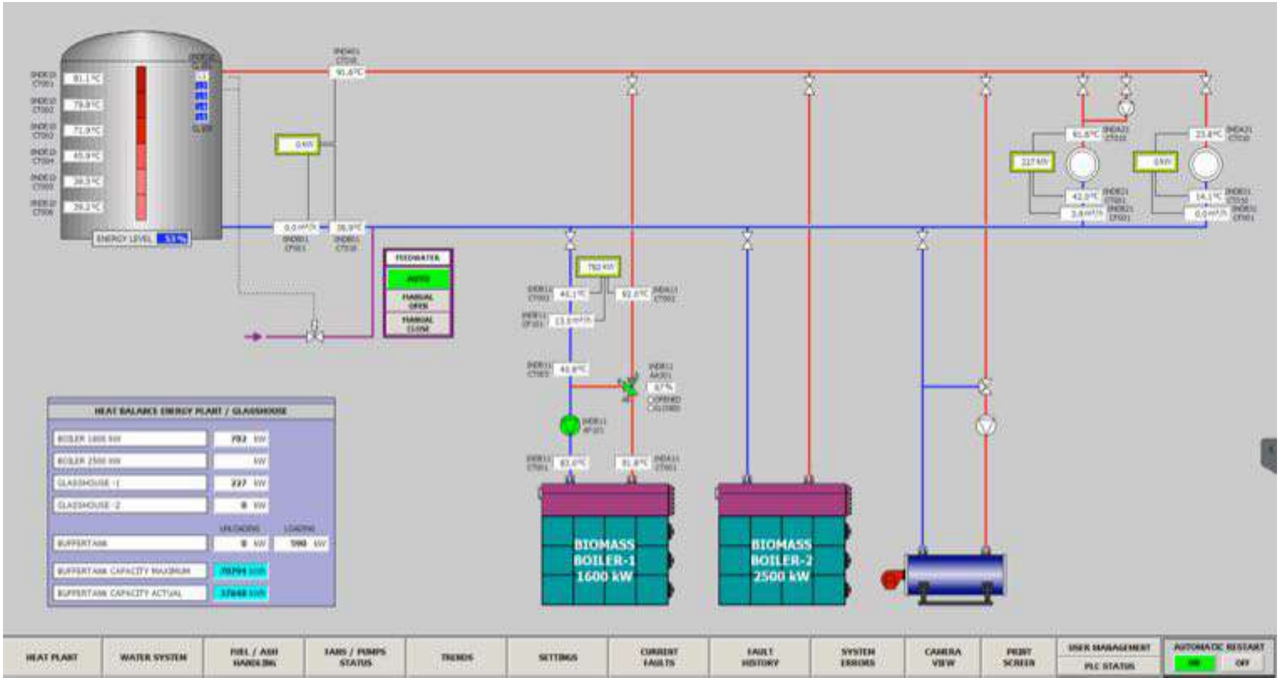

Fig. 17: Showing the two wood boilers and the diesel boiler (now removed), as well as the buffer tank

b. Fuel supply risk

In this case the site had already been using wood chip for eight years. It was familiar with the supplier, who has proven reliable and trustworthy, delivering consistent fuel of the right quality when required. If that supply chain has an unexpected interruption, there are other established wood fuel suppliers feeding the demand in Christchurch. There is little or no risk regarding fuel supply.

c. Fuel reception risk

There are various methods that can be used to get the wood fuel from the delivery truck into the fuel store. With walking floor systems or Toploader systems the truck can reverse into the store and discharge directly into it. Although this site has a walking floor system, the fuel is actually received onto an open-air concrete pad. A member of Zealandia staff then jumps on a tele-handler which is used to transfer the fuel into the store – through the door that can be seen to the right below.

So there is some small risk around the reliability of the tele-handler, but this is in reality zero-risk as they are very reliable and any problem can be quickly fixed, long before the fuel store runs dry.

Fig. 18: Showing the fuel reception area and the telehandler used to insert the fuel into the store

The main risk around fuel reception is that the fuel is delivered late in the day and it rains hard all night, before it can be put under cover. However the wetter fuel will be blended to a certain extent by the loading-in process and the action of the walking floors in the fuel store, and the new boiler is very capable of handling damper fuel.

Ideally any machinery between the truck and the fuel store is best avoided, and is best 'designed out' if possible by tipping directly into the fuel store.

d. Fuel storage risk

See Extended Case Study 6 for a discussion of the ideal size of a fuel store, in terms of days of energy use. An under-sized fuel store will result in frequent deliveries being required, as well as the need to run the store very low before deliveries, thus increasing the risk of a supply interruption. This fuel store is approx 9m x 9m, so holds about 250-300m^3. This has been ample when running at an average load of under 1MW. On cold days the 1.6MW boiler uses approx 35-40m^3 of wood fuel, so about a week of mid-winter usage is currently available – a nice situation.

However, when the extra 2.0 hectares of heat demand comes on stream, potentially more than doubling existing demand, the store will be on the small side, and will need to be topped-up prior to a long weekend if no deliveries can be made for three days. A further expansion is muted, at which point the store will definitely need expanding in some way.

To address this Vince is planning to increase the outside bunker storage capacity, and also make loading easier using a ramp. This will enable the blending of fuels on site for optimum results.

e. Fuel recovery risk

The term 'fuel recovery' refers to how the wood fuel is reclaimed from the store. For smaller boilers a wood chip 'agitator' is used (see Extended Case Study 6 and 7) which are useful in helping to overcome bridging issues – but they are not appropriate for projects of this size. For larger projects, over say 1MW, a walking floor fuel recovery system is common, or overhead grabs, or more recently the Toploader rake system is becoming a more common alternative in Europe and Australia.

In this case the project benefits from a proven pre-installed system, being 6 x reciprocating walking floors. These are driven by a hydraulic power pack and oscillate backwards and forwards, pushing the pile towards a drop-off. This is a robust system with very little risk, and capable of handling the largest category of wood fuels. In some cases, if the fuel is wet or there is heavy use, parts can either rust or wear out, and in cases of particularly high throughput, the concrete floor may need to be re-surfaced every 10 years or so.

f. Fuel transfer risk

As discussed in earlier sections, the wood fuel had been pneumatically conveyed from the walking floor fuel store to the old Vekos boiler. With the upgrade to the boilers, it made sense to eliminate another risk point, so the fuel transfer system was also upgraded. Previously the five walking floors dropped fuel into an auger that fed the paddle fan to blow the chip. The auger has been replaced with a chain conveyor, and this feeds to a second chain conveyor which transports the fuel to the boiler house, to a location between the two boilers in fact.

At this point the wood fuel needs to be distributed between the two boilers. This is achieved with a large dual-direction auger. The photo below shows the size of the auger – see the head at the bottom of the picture.

Fig. 19: Showing the dual-direction auger distributing fuel between the two boiler day bins

This auger responds to signals from the day bin of each boiler – one is just visible above left – to keep them topped up with fuel, so the boiler can be stoked.

Overall, the fuel transfer system is designed and built to be a standard that makes it tolerant of fuels with high levels of contaminants and even the odd spanner or small boulder.

On this project, the walking floor feed to a chain conveyor fuel transfer system, discussed below.

g. Boiler fuel feed risk

With the Vekos, the wood fuel was dropped into the top of the boiler after being separated from the airflow using a cyclone.

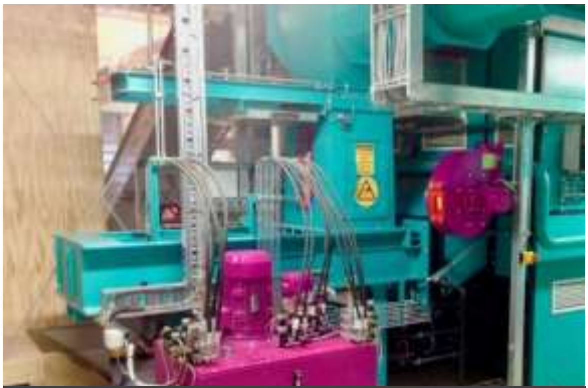

Fig. 20: Showing the ram feed. Note the gate valve above the day bin. And the hydraulic pack (pink).

The new boilers require the fuel to be fed onto the reciprocating grate. So, once the biomass has been conveyed all the way to the boiler day bins, it has to enter the combustion chamber.

These boilers use a ram stoker system to push the fuel into the boiler.

Alternatives to a ram are a single or double auger system, but ram stokers are the most robust method, and are the least susceptible to blockages. They have a cutting blade at the leading edge, designed to cut through any over-sized wood fuel. It would be hard to install a lower-risk system.

Risk Summary This project has all the potential risks well covered, from boiler reliability and fuel flexibility to fuel supply and emissions control. In addition the entire fuel handling system, shown below, is extremely robust.

Back-up is provided by the dual-boiler approach, which affords a certain amount of redundancy. Even if the large boiler fails during a cold snap, the other boiler will still be able to supply enough heat to at least protect the plants from frost damage whilst the boiler problem is rectified, especially with a charged buffer tank to call upon.

All of the fuel recovery, transport and stoker equipment is very robust, and designed for the widest possible range of fuels, up to hogged forest biomass and bark. Every possible risk has been minimised

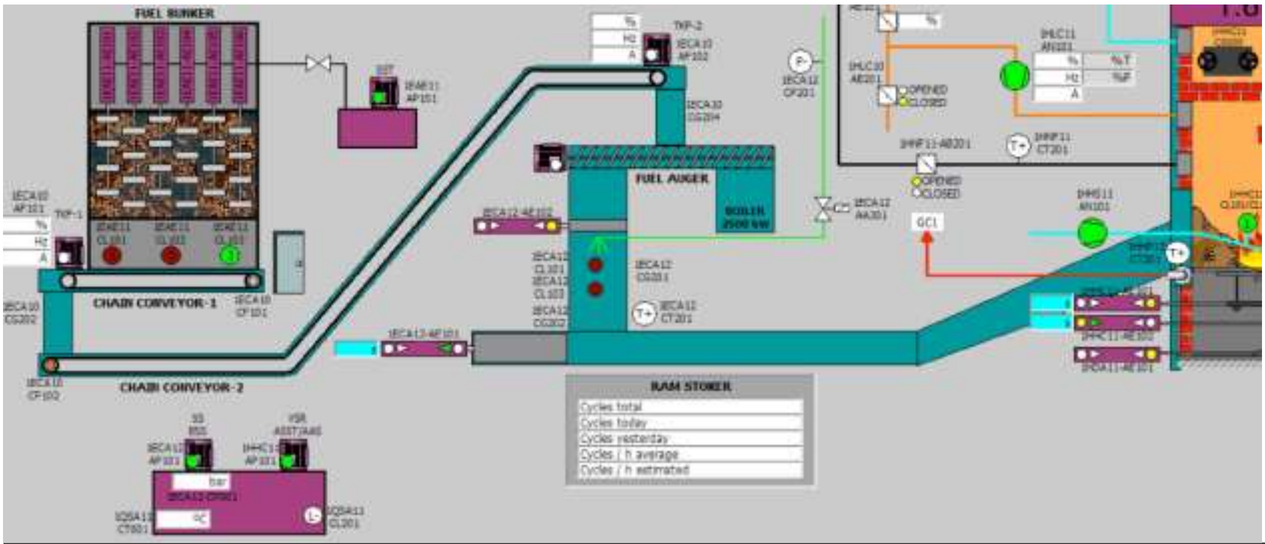

Fig. 21: Showing the fuel recovery, transfer and feed system, starting with the 6 x walking floors.

6. SUMMARY – WALKING THE TALK OF SUSTAINABILITY

The Wylaars and business partner Graham Windross have wisely invested in the long term. The cost of the state-of-the art wood boiler was covered by avoiding a baghouse and selling the old boiler – and this has delivered significant operational advantages, in terms of automation, reliability and flexibility.

Additional investment has been made in the fuel transfer system, to ensure its resilience matches that of the new wood boilers. The brothers now have a site that is well set-up to have reliable and low-cost heating for decades to come.

This case study represents an excellent example of how investing a little more in a modern wood boiler system represents a better investment than further investing in a relatively fuel-inflexible 'multi-fuel' boiler. By adopting a longer term approach the brothers are reaping multiple benefits:

1. Avoided higher operational cost of a baghouse (new bags, and higher electricity)
2. Avoided increased fire risk from the baghouse, and possible associated insurance hikes
3. Greater fuel flexibility. The site is no longer reliant on a 'premium' wood chip, and can accept a wider range of fuels, opening up future possibilities
4. Greatly increased tolerance to fuel particle size – now over-size pieces won't cause blockages
5. Reduced fuel usage due to the improved efficiency of the sophisticated boiler
6. Avoided manual de-ashing – the new boiler does all its own de-ashing to external ash bins
7. Better performance records from the advanced interface screens and data logging. It is now known exactly what is happening – and what has happened – from the trends graphed over the last days and weeks
8. Now that the site has 100% carbon-neutral heating, any carbon price risk has been

eliminated, as has exposure to the price of LPG or diesel as a back-up

All these are benefits delivered by long-term thinking, and they are about to be multiplied as the expansion plans are realised. Above all, the owners have peace-of-mind knowing they have not only future-proofed the sites heat supply, but have done the right thing from an environmental perspective, whilst setting the site up to enjoy a sustainable and prosperous future.

Parting Comment Vince Wylaars, co-owner and MD said "We are very convinced that biomass heating is the way to go for our type of business, so much so that we have installed an additional boiler in our new location in Auckland. In the future as the industry matures some of the challenges we currently have will diminish".