ENERGY CONVERSION OPTIONS

HILLMORTON HOSPITAL

29th September 2008 | Issue A | 090546/M/1

consulting engineers
heating + ventilation
mechanical
structural
hydraulic
electrical
acoustic
civil
fire

Unit 3,Amuri Park
Cnr Bealey Ave & Churchill St
P.O.Box 25-108,Victoria St
Christchurch 8144
New Zealand
(03) 366-1777: phone
(03)379-1626: fax
engineering@pfc.co.nz: email
www.pfc.co.nz: website

1. Introduction

This report was commissioned by Alan Bavis and Terry Walker of the Canterbury District Health Board. Its purpose is to identify the viable energy alternatives and plant options which are available for the Hillmorton Hospital site and to make a positive recommendation as to that which is the most appropriate, both technically and economically.

It builds on an earlier report by Alan Bavis and Tim Emson which gathered together and analysed the base data for the site and had gone as far as to look at initial plant configurations and ballpark costs. This report extends that work.

2. Summary

The report set out to look at two fuel alternatives (wood pellets or chip), and a number of alternative plant configurations.

The fuel alternatives widened to 4, with one supplier offering (in addition to the requested specification of chip) a much finer and drier chip, and another a recycled oil very similar to light furnace oil (LFO). Neither of these alternatives were known when the report was commissioned, but it seemed wise to include them.

The plant alternatives looked to be either a centralised option based on the Energy Centre with Ferguson and the Recreation block added, or a decentralised option, giving Ferguson and/or the Recreation block their own localised boilers.

In the event, the decentralised options proved to be significantly more expensive than a centralised alternative, with no apparent operational benefits. Once that was identified, they were not developed further.

The report therefore looks at 3 basic alternatives for centralised boiler plant; wood pellet, a medium sized air dried wood chip, and recycled oil. A 4^{th} variation which assumes that plant designed for pellet operation could be used with a fine, dry wood chip has also been tabled.

3. Recommendations

The most attractive alternative both economically and technically is to convert one of the existing Energy Centre boilers to operate on recycled oil and replace the other with a wood chip boiler manufactured locally by Scott's Engineering.

If it was felt that the future of the Energy Centre was so uncertain that any long term investment might be unwise, the lowest capital cost alternative is to convert both of the existing boilers to recycled oil operation. At 3 years, the NPV of this option is only a little less than that of the recommended alternative.

In the mean time and as soon as possible, the firing hours of the existing boilers must be logged. Such data is essential to the accurate sizing (and therefore costing) of replacement boilers for any of the wood firing alternatives. It may well be possible that with the resulting data to reduce the size and capital cost of any replacement boilers.

4. Base Data

The CDHB spreadsheet "Hillmorton Heating – 1 .xls" gives the following summary of energy use between 2002 and 2008.

	GJ	kWh
2002/3	25,986	93,550,939
2003/4	26,165	94,194,562
2004/5	29,313	105,526,966
2005/6	28,107	101,186,604
2006/7	28,277	101,798,280
2007/8	24,520	88,270,200
Average	**27,061**	**97,421,258**

Taking the average as a basis for comparison,

Fuel	Unit	$/Unit	CV (MJ/unit)	$/GJ	c/kWh	Annual Cost
LPG				$35.23	12.7	$953,375
Diesel	litre	$1.10	38.1	$28.87	10.4	$781,302
Wood Pellets	tonne	$340.00	19	$17.89	6.4	$484,258
Wood Chip (S50, M40)	tonne	$105.00	13.1	$8.02	2.9	$216,905
Wood chip, kiln dried	tonne	$200.00	17	$11.76	4.2	$318,370
Reclaimed Oil	litre	$0.60	38.1	$15.75	5.7	$426,165

This table is used in the economic analysis of section 9 to make the economic case for conversion.

5. Energy Options

Diesel oil has been discounted from the start as an alternative fuel on the grounds of price, price instability, and carbon footprint. There would be little advantage in converting from LPG.

3 alternative fuels have been considered; wood pellets, wood chip, and recycled oil.

Recycled oil is a late-comer to the project. It has recently become available through Solid Energy as a by-product from the recycling of used lubricants. Whilst not a renewable fuel in the same sense as wood energy alternatives, it is "green" in that it is a recycled product. On this basis it has been included in the discussions.

5.1 Wood Pellet

Wood pellets are a manufactured fuel and produced in Rolleston (just outside of Christchurch) and Rotorua. Other players are slowly entering the market, although they tend to be small and local.

Boiler plant to burn pellets can be identical to that which is used to burn coal, or alternatively the more sophisticated European biomass boilers (Koeb, Heizomat, Binder, KDG, Faci or the like) can be used.

Pellets burning in an underfed sectional boiler, Rudolf Steiner School, Christchurch.

Benefits

- Carbon neutral (almost).
- Clean burning
- The ash is a useful fertiliser. (Most users dispose of it in their gardens.)
- Pellets flow and handle easily through the fuel transport and boiler equipment. In many ways they behave more like a liquid.
- With electric ignition boilers can be allowed to go out in the knowledge that they will automatically re-ignite when required. "Kindle" is no longer necessary.
- The fuel is indigenous, sustainable and renewable.
- The ash generated is about 10% that of coal

Limitations

- There is only one supplier of pellets at this time.
- Pellets are significantly more expensive than wood chip
- The quantities required by this project necessitate truck-trailer units coming from Rotorua, with knock-on effects on the required fuel storage volume.

5.2 Wood Chip

Wood chip in most respects is very similar to wood pellet. It is however a highly variable fuel depending on source, production method, and moisture content.

There are essentially two methods of preparation; hogging or chipping.

Chipping is when wood is broken down by a set of knives into small clean cut pieces.

Hogging is when the wood is broken down using a hammer process into smashed up lumps.

Both methods of fuel preparation are commonly used.

Having been chipped or hogged the product is screened to take out the over and undersized particles, and then it may (or may not) be dried to produce a consistent product.

The degree of sophistication of equipment necessary to burn chip is a function of the method of preparation and fuel consistency.

At one extreme, a well cut, well graded, kiln dried chip will flow and burn as well as wood pellets, and will burn with the same boiler and fuel handling equipment.

At the other extreme is a roughly graded hogged product that binds together easily and which has had no drying barring that which occurred naturally between the time it was hogged and the time it was burned. At this extreme, either one of the Foggarty (Invercargill manufacturer) stepping grate boilers or the sophisticated purpose-built European boilers and fuel handling systems is required. Although these boilers are generally more expensive than their simpler coal and pellet counterparts, they allow the burning of relatively cheap chipped or hogged fuels.

The proposed wood chip specification is the BioEnergy Association grade S50M40. (Briefly, S50M40 has a 50mm cross section. The coarse fraction of the chip (which may be up to 20% of the total) can be up to 12cm long. Fines are allowed to be up to 5% of the total weight. Moisture content maximum is 40%)

Benefits

- Carbon neutral (slightly more so than pellets with a little less energy involved in its production and transportation).
- Clean burning
- With electric ignition the boilers can be allowed to go out in the knowledge that they will automatically re-ignite when required.
- The fuel is indigenous, sustainable and renewable.
- Potentially, large quantities are available.
- The ash generated is about 10% that of coal

- The ash is a high value fertiliser. (Most users dispose of it in their gardens.)

Limitations

- The wood chip industry is in its infancy and at this time the consistency (or otherwise) of the locally produced product is untried.
- There is no long-term track record for any supplier, although a number of suppliers in New Zealand are well established companies in other areas of business.

5.2.1 Wood Chip Suppliers

Two woodchip suppliers have been approached to supply chip to the S50M40 grade; City Firewood and Crusaders Garden Makers. The Outline Specification to which they have been asked to quote is attached as Appendix 1.

Appendix 2 is their actual responses.

In summary the main points of each are:

City Firewood

- Claim to have no problem supplying the S50M40 chip from seasoned logs.
- Cost is $100-$110/tonne. (at 40%, approx. $7.65 to $8.40/GJ)
- Claim that they will produce a chip to a tighter size distribution than the specification calls for.
- Can also provide much finer fuel and much lower moisture content, kiln dried to a CV of 17GJ/tonne. (implies a moisture content of around 10%). Cost for this product $200-$250/tonne. (at 10% moisture content, approx $11.75 to $14.70/GJ)

Crusaders Garden Makers

- Also claim to have no problem with supplying the quantity required.
- Product is air dried, and they claim to get to 30% moisture content without too much difficulty.
- Cost $102/tonne. (Approx. $7.80/GJ) Willing to commit to a 5 year contract with CPI adjustment.

Comments

Supply does not seem to be a problem. With the S50M40 chip either City Firewood or Crusaders are willing to supply.

The offer of finer kiln dried chip from City Firewood opens an additional possibility; that of running chip in a boiler which might normally be used for pellets with the capital savings which would follow. Running a finer drier chip makes fuel storage and transportation considerably easier that it might otherwise be.

The risk is (to an extent) that one would be committed to a single source of supply. Only City Firewood has the kiln equipment and kiln to produce the chip. The risk is balanced however by the fact that the equipment that would burn such chip would also burn pellets with equal ease.

5.3 Recycled Oil

Recycled oil is a relatively new fuel, being a light furnace oil derived from waste lubricating oils. (It is in fact lubricating oil that has been well filtered and de-watered.) It has a calorific value close to diesel oil of about 38MJ/l. (The data is attached as Appendix 3.)

Storage is in a conventional tank, and distribution via a conventional ring main system incorporating a line heater for cold weather and a filter before entry to the burners.

Enquiries to date suggest that there are no particular environmental problems associated with burning the fuel and that granting of a Resource Consent should require nothing unusual.

The attraction of this option is that the existing boilers could be retained with a simple change of burner. The required equipment would be:

- 2 burners to replace the existing gas units. They will need LPG ignition systems.
- About 30,000l of storage to give a week at the heaviest time of year.
- A line heater for winter, to ensure no problems at the coldest time of year.
- An oil transfer set (run and standby pumps)
- A filter before the burners.
- A spill back pressure regulation valve.

Benefits

- This option requires the minimum of changes to the Energy Centre
- It has the lowest capital cost
- Both boilers can be converted.
- The fuel is "green" to the extent that it is a recycled product.
- Delivery and storage is the easiest of all options.
- There are no ash residues.

Limitations

- There would appear to be no obvious limitations, being a slight variation only on normal liquif fuel firing.
- The only drawback may be the how it might attract a carbon tax in view of the fact that the original oil from which it was derived is a fossil fuel.

6. Possible Plant Configurations.

There are two basic plant configurations; centralised or decentralised. Each configuration is operationally possible in that there is adequate space for fuel storage and delivery and that either plant arrangement will meet the need. Either alternative will have a very similar operating efficiency so that fuel costs are unlikely to be significantly different between them. Operating costs will be lower for a single centralised boiler.

The decision between the two options hinges around the relative cost of decentralised boilers against a slightly larger centralised boiler and the necessary extension to the heating mains. (To handle Fergusson and the Recreation blocks from a central plant.)

6.1 Decentralised

A decentralised plant would replace at least one of the Energy Centre boilers with an alternative, and both of the steam boilers at Fergusson and the Recreation Centre.

Looking at Ferguson and the Recreation Centre there is no need for steam in that there are no dedicated steam loads. All steam in both cases is converted to either domestic, or low temperature hot water for heating.

The replacement plant therefore can be low temperature hot water (LTHW) directly connected to the space hearing loads, generating domestic hot water via plate heat exchangers. This is a straightforward and conventional conversion.

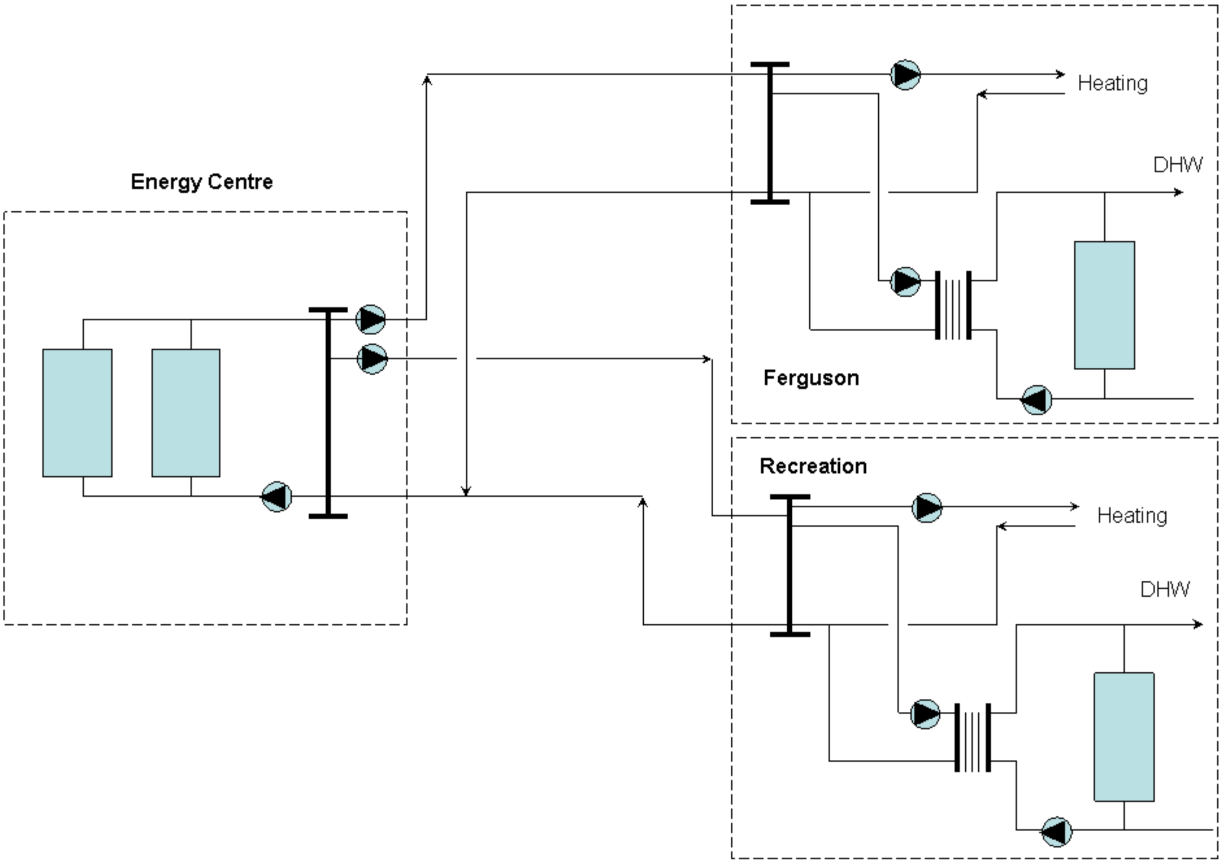
There is adequate space in both the Ferguson and Recreation centre plantrooms for the necessary pumps and heat exchangers, although not for the boilers and fuel stores. In the case of Ferguson, if the plantroom was modernised with plate heat exchangers and smaller DHW storage vessels (which is possible with plates), then it may be possible to house a boiler in the existing plant room space. However, a fuel store and transfer equipment would still be needed.

The Recreation Centre would require a complete new boilerhouse structure and fuel store.

6.2 Centralised

To centralise all heating to the Energy Centre would involve laying a pair of pipes between the Energy Centre and both Ferguson and the Recreation blocks. At the point of entry to each building would be placed a header, distributing hot water directly to the building heating circuits, and indirectly via heat exchangers to domestic hot water generation.

Schematically, a centralised boilerhouse is shown on the next page. The schematic shows no heat exchangers on the heating circuits in Ferguson or Recreation, as it is entirely possible to re-arrange them slightly to be injector circuits which will mix medium temperature hot water from the Energy Centre down to the local circulating temperature. If there was an overriding reason to keep the Energy Centre circuit separate to the Ferguson and Recreation circuits, then an additional set of plates would be used in each.



6.3 Centralised or Decentralised?

The deciding factor (to centralise or not) is the relative cost of separate boilers against a trench and pair of pipes from the Energy Centre. (On the assumption that all other equipment and installation costs are virtually the same for centralisation or decentralisation.)

David Browne Contractors have installed a number of buried pipework systems in recent times. They suggest a unit rate for trenching and a pair of 110mm pre-insulated pipes as being $662/m. If the distance between the Energy Centre and Ferguson is taken as about 215m, the cost becomes $142,000.

A budget price from Spark Energy (Koeb boilers) is $190k for the boiler and fuel feed equipment. On top of that is installation.

Similarly a budget price for a Koeb boiler for the Recreation Centre is $70k.

In both cases, if demolitions, boilerhouse, and fuel store construction is added in, the costs associated with decentralised solutions will be considerably more than installing a single slightly larger boiler at the Energy Centre and laying 2 sets of connecting pipework.

Additionally, the O&M cots associated with 3 boilers in 3 separate locations will be significantly more than attending to one slightly larger unit.

On this basis, decentralised solutions have not been developed further.

7. Scopes of Work

The schematic (Appendix 3) shows the main features of a decentralised system. All alternatives share the same schematic. The difference between each is the replacement boiler in the Energy Centre.

7.1 Boiler Size

There is an unknown in the size of the boiler required. If the worst three months of 2005/6 are taken as representative of the maximum likely load, the total energy consumption was 2,718 GJ, which averages over the period as a load of about 1050kW. This is $2/3^{rd}$'s the capacity of one boiler.

Likewise, taking a typical 3 month summer period, the lowest load has been 2007/8, December, January & February with an energy consumption of 830 GJ, or an average of 320kW.

Neither of these values can be taken as representing a peak instantaneous load, but they do suggest that the present boiler plant may well be oversized.

The way to resolve the unknown would be to set up a logging system on the burners of each boiler to record running hours. From the record of running hours during cold conditions the actual likely peaks of demand could be estimated and a replacement boiler sized accordingly. Before a final boiler size is selected must be done.

For the purposes of this analysis, a 1.5MW boiler (the same as existing) has been be assumed. The consequence however is that the capital costs will be slightly overstated. There is also the possibility of using a somewhat smaller boiler with a storage vessel, (with the resultant capital savings) if it can be shown that there are significant short term peaks to the load.

7.2 Wood Chip

Under this option the replacement boiler would be a unit capable of burning the BioEnergy Association S50M40 grade of chip. (50mm cross section, 40% moisture content maximum). This is classified as a "medium" chip. The boiler installation must be capable of particulate emissions of less than $100mg/m^3$. (All school boiler pellet installations engineered by Powell Fenwick to date in Christchurch have been granted Resource Consents by ECan at 125mg/m3 and there is no reason to believe that this installation should be any different.)

The essential Scope of Work would be.

Energy Centre

- Remove one existing boiler and pass it to the CDHB for disposal. There are two boilers and either could be replaced. Given that the fuel store will be to the left of the boilerhouse (when standing in front of the boilers), it is probably the left boiler which would be the easier to remove. This should be confirmed with the chosen boiler provider.
- Supply and install a single 1.5MW wood chip boiler capable of burning S50M40 chip. (Living

Energy, Spark Energy, Scott's Engineering, Foggarty Engineering, Earnslaw Bio-energy and Taymac are all capable of supplying such boilers.) At this time there is no preference, but each will give rise to a slightly different plant configuration. Note also that some boiler types will require a bag-filter to achieve the required particulate standard.

- Arrange pipework, valves & pumps as shown on the schematic of appendix 5
- Modify the existing building management system to provide control of the wood boiler and retained gas boiler.
- ***Either***, install 2x50m^3 silos adjacent to the boilerhouse to provide fuel storage. The silos to be supplied complete with an elevator system capable of taking the discharge from a tip-truck, and filling the silo from empty to full within 30 minutes. The silo to be supplied complete with an outlet dust filter. (See Springston Agricultural Engineering or Taymac)
- ***Or*****,** provide a tipping floor of about 75m2 with a hydraulic "walking" floor to "pull" chip to a feed auger to supply the boiler. (See Scott's Engineering or Taymac)
- Check with the boiler supplier on the size and height of the required flue and if necessary, install a new stainless steel unit. Otherwise, allow to modify the connection to the existing flue to suit.
- Provide ashing-out containerage.

The Energy Centre showing the flues and area at the end for a fuel store.

Ferguson Block

- Remove all existing steam to water heat exchangers.
- Remove the existing DHW calorifiers.
- Trench and install approximately 215m of 80nb "Insapipe"
- Install new pipework and valves as shown on the schematic.
- Install new variable speed pumps, run & standby, 6.2l/sec @ 150kPa
- Install a new DHW plate heat exchanger of 150kW and a 3000l storage vessel.
- Install controls as detailed in the control section.

Recreation Block

- Remove the existing steam boiler.
- Trench and install approximately 100m of 50nb "Insapipe"
- Install new pipework and valves as shown on the schematic.
- Install new variable speed pumps, run & standby, 1.8l/sec @ 20kPa
- Install a new plate heat exchanger of 50kW and a 500l storage vessel.
- Install controls as detailed in the control section.

Controls

A BMS shall be allowed to control the energy centre boilers and all plant in Fergusson and the Recreation Centre.

The BMS shall:

- Provide start/stop time control for the boilers and all individual plant items.
- Run/standby control of the boilers.
- Temperature indication for:
    - F&R to Fergusson
    - F&R to Recreation
    - F&R DHW plate secondary , Ferguson
    - F&R DHW plate secondary, Recreation.
    - Storage tank top, middle, and bottom temperature, Fergusson.
    - Storage tank top, middle, and bottom temperature, Recreation.
    - Control of the VSD pump on the primary to the DHW, Fergusson to regulate output temperature.
    - Control of the VSD pump on the primary to the DHW, Recreation to regulate output temperature.
    - F&R temperatures on the secondary side of the mixing bottle, Fergusson.
    - F&R temperatures on the secondary side of the mixing bottle, Recreation.
    - DHW return temperature, Fergusson.
    - DHW return temperature, Recreation
    - Ambient temperature
- To pick up the common boiler alarms for each boiler.
- Allow a high level interface to the new pellet or chip boiler to carry across selected operating data to the BMS. (Typically main operating parameters, alarms, running hours and the like.)

7.3 Wood Pellet

The Scope of Supply is virtually identical to 7.2, Wood Chip, saving only that:

- A wood pellet boiler would be substituted for the wood chip unit. Such a boiler is somewhat simpler and should offer a significant capital saving.
- The fuel storage option would only be silos.

All other requirements are the same.

7.4 **Conversion of Both Existing Boilers to Recycled Oil.**

In this case the Scope of Supply would be identical to wood chip and pellet insofar as the addition of Ferguson and the Recreation Blocks go, but the work in the Energy Centre would be very different.

The Scope of Work would be:

- Remove both of the existing gas burners and replace them with similarly sized units capable of burning light furnace oil. (Specification of a very similar oil is attached as appendix 2)
- Install a double walled oil storage tank of 30,000l on a concrete base.
- Install an oil transfer set with run and standby pumps.
- Install a line heater.
- Install all associated oil transfer pipework.

8. Budget Costs

	PBS				David Browne				Taymac
Item	Pellets (Taymac)	Binder	Kob	Taymac (Chip)	Pellets (Taymac)	Binder (Living Energy)	Kob (Spark Energy)	Taymac (Chip)	Recycled Oil
Energy Centre									
Demolitions & strip out	$10,000	$10,000	$10,000	$10,000					
New boiler	$150,000	$1,220,000	$850,000	$400,000					
Fuel storage and transportation	$200,000		$200,000	$200,000					
Pipework modifications	$20,000	$20,000	$20,000	$20,000					
Insulation	$2,000	$2,000	$2,000	$2,000					
Flue	$12,000	$12,000	$12,000	$12,000					
Controls	$40,000	$40,000	$40,000	$40,000					
Other									
Sub-total Energy Centre	**$434,000**	**$1,304,000**	**$1,134,000**	**$684,000**					**$159,532**
Ferguson									
Trenching and pipework complete	$140,000	$140,000	$140,000	$140,000					$140,000
Pumps & connections in Energy Centre	$10,000	$10,000	$10,000	$10,000					$10,000
Strip out of redundant plant in Ferguson plantroom	$10,000	$10,000	$10,000	$10,000					$10,000
DHW heat exchangers and storage vessels	$40,000	$40,000	$40,000	$40,000					$40,000
Pipes & valves	$20,000	$20,000	$20,000	$20,000					$20,000
Insulation	$2,000	$2,000	$2,000	$2,000					$2,000
Controls	$14,000	$14,000	$14,000	$14,000					$14,000
Others (Pumps)	$5,000	$5,000	$5,000	$5,000					$5,000
Sub-total Ferguson	**$241,000**	**$241,000**	**$241,000**	**$241,000**					**$241,000**
Recreation									
Trenching and pipework complete	$60,000	$60,000	$60,000	$60,000					$60,000
Pumps & connections in Energy Centre	$10,000	$10,000	$10,000	$10,000					$10,000
Strip out of redundant plant in Ferguson plantroom	$2,000	$2,000	$2,000	$2,000					$2,000
DHW heat exchangers and storage vessels	$10,000	$10,000	$10,000	$10,000					$10,000
Pipes & valves	$10,000	$10,000	$10,000	$10,000					$10,000
Insulation	$1,000	$1,000	$1,000	$1,000					$1,000
Controls	$14,000	$14,000	$14,000	$14,000					$14,000
Others	$3,000	$3,000	$3,000	$3,000					$3,000
Sub-total Recreation	**$110,000**	**$110,000**	**$110,000**	**$110,000**					
Total (David Browne Only)					**$497,075**	**$1,426,875**	**$1,340,075**	**$997,575**	**$510,532**
Contingency	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Grand Total	**$835,000**	**$1,705,000**	**$1,535,000**	**$1,085,000**	**$547,075**	**$1,476,875**	**$1,390,075**	**$1,047,575**	**$560,532**

For the economic analysis, the project costings for Taymac boilers has been assumed for pellets, and Kob for wood chip.

The total cost for the recycled oil project has been calculated by taking the Taymac price for conversion of the boilers to oil and adding PBS's costs for the addition of Ferguson and the Recreation block.

9. Economic Analysis

9.1 Underlying Assumptions

9.1.1 LPG

If all but one of the wood pellet / chip options are chosen then one LPG boiler will be retained as a back-up in case of failure and for peak winter loadings. Not all of the fuel savings which might accrue from conversion will therefore apply. In the absence of detailed daily usage data (which would give load profiles winter and summer), it is no more than an estimate as to how much LPG might still be used.

Looking at the historic monthly data, it is clear that under most circumstances a single 1.5MW boiler ought to handle the load easily. On that basis, it is probably conservative to say that 20% might still be handled by LPG.

This is not the case for the recycled oil alternative as there is no reason not to convert both boilers immediately. 100% savings will apply.

Note also that the current price for LPG has been assumed in this analysis. Almost certainly the price will increase as soon as the intention to convert away from it is announced.

9.1.2 Timescales

A number of scenarios have been looked at, the results of which are printed on the following pages.. 4 timescales have been used; 3, 6, 10, and 30 years, 30 years representing the likely “Lifetime” of an installation.

9.1.3 Inflation

No attempt has been made to factor in the effects of a rising LPG price (in real terms) because there are too many unknowns. It is a safe assumption however that the price will rise more rapidly than the general Consumer Price Index (CPI).

All other fuels are assumed to inflate at the rate of the CPI, which means that there is no effect on the relative economics of each fuel. (Each supplier has indicated that it would like CPI adjustments in any fuel supply contract.)

9.1.4 Electrical Costs

There will be an electrical operating cost associated with each option for fans and pumps. Again, what that cost might be depends very much on usage. It is reasonable however to say that it would be closely similar across all options, so that even if there was an error in its calculation, it will not distort one option in relation to another. It is also a relatively minor cost compared to the base fuel costs.

The electrical cost has been calculated on the assumption that the circulating pumps to Ferguson and Recreation operate continuously, and that the domestic hot water primary and secondary pumps run for 20% of all hours. It has been deducted from the annual operating savings and is incorporated in the column headed "Annual Savings over LPG etc….". The value used is $4,300p.a.

9.1.5 Standing Losses from Mains

Similarly, there are heat loses from the new buried pipework to Ferguson and Recreation. They have been calculated as 1300GJ/year (assuming that the mains are always hot, which they would need to be to provide domestic hot water). The losses have been back-calculated to a cost dependent upon what the source of energy is, and assuming a boiler efficiency of 80% across all options. The resultant dollar value has been added to the basic energy cost for each energy type that was calculated as being the equivalent of the LPG burned.

9.1.6 Combustion Efficiency

Across all alternatives, it has been assumed that the combustion efficiency is much the same. Again, it is not entirely true, but we can expect a similar efficiency between gas and recycled oil. Wood pellet boilers can easily achieve efficiencies in the low 80%'s, as can wood chip units. However, the efficiency of wood chip is heavily influenced by the moisture content, so that if the chip moisture content is higher than expected, the efficiency will drop.

9.1.7 The Economic Scenarios

With the preceding assumptions in mind, 8 scenarios have been looked at.

The base case assumes that 20% of the total energy required still comes from LPG, and that all of the four technical options are deliverable at their respective budget prices.

The second case looks at the effect of under-estimating the LPG usage, and assumes that 30% of the total energy comes from LPG.

The next four cases are the same as the base case, but looks each in turn at the effect of the capital cost on the relative economic ranking of each alternative if the capital cost of that alternative was actually 10% higher than expected.

The penultimate case is for illustrative purposes only. Taymac are designing a new wood chip boiler to compete with the European imports. They are projecting a very low price. If this boiler was to come onto the market, and if Taymac can provide adequate support, then it could be an attractive proposition.

The last case is to install a single Scott wood chip boiler to meet the baseload winter and summer, and to convert the retained boiler to recycled oil.

The economic model is in the form of an Excel spreadsheet, so that any input variable can be altered and the effects on the economic performance of all or any alternative seen immediately.

Net Present Values have been calculated for each project by summing the savings associated with each project over a series of differing time scales and subtracting from that sum the original capital cost.

Simple payback periods have also been calculated (Capital cost divided by annual savings), and then NPVS at 3 years, 6, 10, and 30 years. (Other periods can be calculated at will if required.)

9.2 **Base Case**

Assumptions

- Capital costs as estimated, Discount rate of 8%, LPG usage with all wood conversions, 20%

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.3 Higher LPG Usage

Assumptions as for the base case, saving that LPG usage is actually 30%

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$303,739	2.7	-$52,236	$569,147	$1,203,111	$2,584,423
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$502,103	3.1	-$241,032	$786,162	$1,834,153	$4,117,568
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$502,103	2.2	$411,093	$1,438,287	$2,486,278	$4,769,693
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$502,103	2.2	$208,968	$1,236,162	$2,284,153	$4,567,568
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$426,820	2.0	$264,957	$1,138,138	$2,028,998	$3,970,049
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	30%							

9.4 Wood Pellet Capital Cost +10%

All other assumptions as for the base case

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.6	-$22,320	$689,096	$1,414,915	$2,996,368
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.9	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$918,500							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.5 Wood Chip (S50M40, Kob Boiler) Capital Cost +10%

All other assumptions as for the base case

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.9	-$208,087	$967,113	$2,166,107	$4,778,534
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,688,500							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.6 Wood Chip (S50M40, Scott Boiler) Capital Cost +10%

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$509,251	$1,684,451	$2,883,444	$5,495,872
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$971,163							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.7 New Taymac (S30M40 Taymac) Chip Boiler

This is shown for illustrative purposes only, as this boiler is only at the design stage.

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	2.1	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	2.1	$286,913	$1,462,113	$2,661,107	$5,273,534
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,193,500							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.8 Wood Chip (kiln dried) Capital Cost +10%

All other assumptions as for the base case

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$340,186	$1,339,372	$2,358,787	$4,579,941
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$918,500							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.9 Recycled Oil Capital Cost +10%

All other assumptions as for the base case

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.2	$665,111	$1,682,563	$2,720,614	$4,982,372
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.5	$710,846	$2,059,576	$3,435,613	$6,433,792
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$616,585							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$988,166							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

9.10 Wood Chip (S50M40, Scott Boiler), + Conversion of 1 Boiler to Recycled Oil, Capital Cost +10%

	Unit	Energy Use ($)	100% Conversion Savings	Annual savings over LPG (assuming 80% for wood fuels)	Simple Payback (years)	NPV (3 years)	NPV (6 years)	NPV (10 years)	NPV (30 years)
Annual Energy Use	GJ	27,061							
Energy Cost, LPG	$	$953,375		0					
Energy Cost, Pellets	$	$513,284	$440,091	$347,748	2.4	$61,180	$772,596	$1,498,415	$3,079,868
Energy Cost, Chip (S50M40, Kob Boiler))	$	$229,906	$723,469	$574,450	2.7	-$54,587	$1,120,613	$2,319,607	$4,932,034
Energy Cost, (S50M40, Scott Boiler)	$	$229,906	$723,469	$574,450	1.9	$597,538	$1,772,738	$2,971,732	$5,584,159
Energy Cost, Chip (S30M40, Taymac Boiler)	$	$229,906	$723,469	$574,450	1.9	$395,413	$1,570,613	$2,769,607	$5,382,034
Energy Cost, Chip (kiln dried)	$	$337,453	$615,922	$488,412	1.7	$423,686	$1,422,872	$2,442,287	$4,663,441
Energy cost, recycled oil.	$	$451,709	$501,666	$497,341	1.1	$721,164	$1,738,616	$2,776,667	$5,038,426
Energy Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$289,776	$663,599	$659,274	1.6	$612,029	$1,960,759	$3,336,796	$6,334,976
Capital cost, Pellets	$	$835,000							
Capital cost, Chip (S50M40)	$	$1,535,000							
Capital cost, Chip (S50M40, Scott Boiler)	$	$882,875							
Capital cost, Chip (S30M40)	$	$1,085,000							
Capital cost, Chip, kiln dried	$	$835,000							
Capital cost, recycled oil.	$	$560,532							
Capital Cost, (S50M40), Scott Boiler + 1x Recycled Oil Conversion	$	$1,086,983							
Discount rate	%	8.00%	**Discount Factors**						
Time	yrs	3	2.577096987						
Time	yrs	6	4.622879664						
Time	yrs	10	6.710081399						
Time	yrs	30	11.25778334						
Proportion of LPG used	%	20%							

10. Discussion

10.1 Technical

The easiest solution is to convert to recycled oil operation. Everything is standard in terms of burners, tankage, and transfer equipment. It also is the least disruptive alternative, requiring only the change of the gas burners for oil, and the installation of an additional oil storage tank.

The chosen route for wood pellets would be to use the current version of the Taymac “Heatpack” sectional boiler, with electric ignition and the most up to date stoker incorporating PLC control and variable speed drives to the fuel auger and supply air fan. Large numbers of thee units are in service and they have adapted readily to operation on pellets (originally having been designed to use coal). Their efficiency (gross) on pellets has been measured in the low 80’s.

Wood chip has more possibilities.

The most attractive wood chip alternative is to use a Scott boiler with a bag house to achieve the requisite emission standards. Scott’s have given verbal assurances that bag replacement is a very infrequent event, and that the presence of a bag house drives very little more in the way of operational costs. It is certainly a much less costly alternative than either of the two European imports.

For the purposes of this analysis, the less costly of the two European options (Kob) have been used. Taymac have offered an entirely new boiler which is under development at the present time. It is designed to use a slightly smaller chip at S30M40. (S50M40 was specified.) It has however a projected price of only $350k ex-works. (c.f. $1.2m for Binder, or $850k for Kob, as detailed in the PBS quotations.) Whilst very attractive, on the grounds that it is a completely unproven design and (so far as is known) it is not even operating in prototype form it has not been pursued at this stage. However, if a decision was made to follow the wood chip route it ought to be considered more closely if Taymac can provide sufficient assurances and support.

Although Kob have been used for the analysis, it does not indicate a preference at this point. There is a consensus between Living Energy (Binder), Spark Energy (Kob), and Powell Fenwick that the requirement for a 1.5MW boiler is probably too large and that the real need is for a unit in the range of 700 – 1000kW. If better data on boiler demand can be generated, the size issue needs to be re-visited. To make a chip boiler competitive with a conversion to recycled oil however, the cost would have to come down a very long way.

10.2 Economic

Looking at the base case (which assumes that for most of the wood alternatives, 20% LPG would still be burned), then the alternative with the lowest capital cost and the shortest payback period is to convert both boilers to operate on recycled oil.

However, looking beyond simple paybacks and capital costs, the alternative that has the greatest NPV at three years is to install a Scott wood chip boiler and convert the remaining existing boiler from LPG to recycled oil. The relative savings of this alternative increase the longer that the NPV is calculated for.

If the quantity of LPG consumed is greater than the assumed 20%, then it favours conversion to a wood chip / recycled oil or straight recycled oil alternative even more, as under either there would be no LPG requirement. It should also be remembered that as soon as the intention to convert is announced, the cost of LPG will increase because the total take will have decreased, so that the analysis which assumes today's price of LPG will be underestimating the likely future costs.

Even if the cost of conversion to recycled oil or a wood chip/ recycled oil combination have been underestimated by 10%, the relative rankings of the projects all the way out to 30 years do not change.

The least attractive option is the installation of an imported wood chip boiler. 3 years out, the project has still not achieved a payback of the initial investment.

As has been previously stated there is a strong likelihood that the existing boilers are significantly oversized. If logging over a period can establish the true maximum load and load range, then it might be possible to reduce the size of a replacement boiler. It might also be possible to adopt a common European practice (now in place in a small number of local schools) of using a large buffer vessel to cope with short term peaks in load, allowing a smaller boiler than would conventionally be selected to be installed.

10.3 **Risks**

Each of the conversions has a different group of associated risks. However, above all of them is the question of the future of Hillmorton Hospital.

If the hospital is likely to remain much as it is for something in excess of say 15 years or so, then any of the alternatives are justifiable.

If there is a reasonable chance that the site is to be significantly redeveloped before then, it probably makes little sense to invest in long term solutions if there is thought that the Energy Centre would be inappropriate for the future hospital. However, such considerations are outside of the scope of this report.

10.3.1 Recycled Oil

- Stability of the supplier. The supplier is Solid Energy. Solid Energy claim to have about 25 million litres available annually, a very large proportion from their own vehicle fleet. They are able to guarantee the long term supply to the hospital.
- Some of the 25m litres come from external sources that are contracted to Solid Energy for only 3 years, which is why they are reluctant to commit to a contract to the CDHB for greater than 3 years.
- Short term failures to supply are probably not much of a risk. In the event of an unforeseen event preventing a delivery from the normal source, the boilers could be run on normal LFO or diesel oil without problem.
- A Resource Consent still has to be granted. Enquiries suggest that it should not be too difficult on the grounds that there are a number of sites in Christchurch burning used engine oil. However one cannot be certain. A Resource Consent may also involve extending the boiler flues, although this is no great expense.

10.3.2 Wood Pellets

- To supply the requisite volume, pellets would have to be bought from Rotorua in truck/trailer units. There is always the possibility of a delay in delivery at that range and with Cook Strait between Christchurch and the source. However, in any contract it should be possible to get Solid Energy to commit to supplying (in emergency situations) from the Rolleston plant.
- Although there is one major source of supply in New Zealand, there are a growing number of smaller local sources. In the not too distant future it is reasonable to assume that alternatives to Solid Energy may become available (as they already are in Timaru). The danger of excessive price rises is probably small.
- A Resource Consent will be required. At this size, it would probably be notified (ECan policy being to notify all applications above 1MW). However, such notification is likely to be limited only to the immediate neighbours.
- The outline specification called for boilers capable of meeting 100mg/m^3 particulate emissions. All of the school conversions and installations carried out by PFC have been granted at emission rates of 125mg/m^3. There is no reason to believe that ECan might insist on anything tighter than this, but one cannot be completely sure.

10.3.3 Wood Chip

- The same provisos in relation to Resource Consent for wood pellets apply to wood chip.
- Whereas wood pellets would preferentially be stored in grain silos and would therefore be safe from the weather, unauthorised access, vandalism, and the like, chip is more difficult to store and is better stored on a tipping floor with mechanical transfer devices such as walking floors to move the chip to the fuel transfer mechanism. Given the open nature of Hillmorton Hospital and its function, making such an area safe from unauthorised access may not be easy.
- Given the cohesive nature of wood chip, many users find it useful to maintain a tractor and front end loader on site to move the fuel heap from time to time.

10.3.4 Wood Chip in a Scott Boiler

- There is little risk in this area. The Scott product is well developed, locally manufactured, and is installed all across New Zealand.
- The one risk is that the bags in thebag house become perforated by hot sparks and require more frequent replacement than the 10+ years that would be regarded as a minimum by the manufacturer.

10.3.5 Wood Chip in a Pellet Boiler

- About 12 months ago Powell Fenwick attended City Firewood’s 1 day trial of a fine dry wood chip using the new pellet boilers (Taymac “Heatpack’s”) at Cashmere High School. The trial was a complete success in that boiler output was maintained, the fuel fed trough the feed system without difficulty, and the emissions were identical to those achieved with pellets. However, there is a long difference between a 1 day trial and constant operation. Before this alternative could be seriously considered, City Firewood and/or Taymac would have to demonstrate the reliability with a long term trial of say 1 month before the CDHB could safely commit to this course of action.

10.3.6 The New Taymac S30M50 boiler

- As previously stated, this boiler is only at the design stage. To make it a possible contender much would have to be done. However, assuming that Taymac do construct a prototype and are able to demonstrate its long term operability, then it ought to be possible for the CDHB to drive a very good bargain with Taymac who will be very keen to get the first units into commercial operation.
- All of the normal risks of being the first to do something apply to this alternative. In mitigation however, the manufacturer’s factory is only 30 minutes from site.

11. Conclusions

- The easiest alternative technically is to convert the existing boilers to recycled oil operation.
- The most solution with the highest NPV under all scenarios is to install a Scott boiler operating on S50M40 wood chip, with the remaining existing boiler converted to recycled oil operation.
- The lowest capital cost alternative with the shortest payback period is recycled oil.
- It is essential to start accurately logging the operating hours of the existing plant now and into the next winter to more accurately size any replacement boiler plant.

12. Next Steps

- Open a serious dialogue with Solid Energy for the long term supply of recycled oil.
- Start logging Energy Centre boiler firing hours as soon as possible.

Brian Anderson

Powell Fenwick Consultants Limited

This report is subject to Powell Fenwick Consultants Conditions of Engagement which among other conditions prohibits the on sale of the report, its use outside this project, and duplication in part only of the report.

The report has been prepared solely for the benefit of our client. No liability is accepted by this firm or by any principal, or director, or any servant or agent of this firm, in respect of its use by any other person. Any other person who relies upon any matter contained in this report does so entirely at their own risk.

Appendixes

1. Outline Fuel Supply Agreement for Hillmorton Hospital

This document seeks to establish the principles and main features which would be required in a contract to supply Hillmorton Hospital with wood chip. Its purpose is to ensure that the hospital receives wood chip of a known specification and price, delivered on time and in sufficient quantity to meet the hospitals needs under all circumstances.
It is partially in the form of a specification, and partially in the form of a questionnaire. Such final supply agreement as might eventuate will be a compromise between what the CDHB would like and what the supplier can reasonably achieve. It will also contain all of the usual legal elements relating to order, payment, delivery, resolution of disputes and the like.

1. Approximate annual energy delivery is likely to be in a range between 24,000 and 30,000GJ. This equates to between 1,800 and 2,300 tonnes (approximately) of radiata pine at 40% moisture content (oven dry method).
2. Maximum likely monthly delivery: 3,700GJ. This equates to 280 tonnes of radiata pine at 40% moisture content (oven dry method).
3. Fuel specification shall conform to the draft Bio-Energy Association technical document 01, “Wood Fuel Classification Guidelines”, grade S50
4. Maximum acceptable moisture content 40% (oven dry method).
5. Please state how the required moisture content will be achieved.
6. Are you capable of delivering reliably to a lower moisture content? If so please state what it is.
7. Please state how the moisture content will be measured. (The docket for each delivery will be required to display the measured moisture content.)
8. Please state your preferred size of delivery vehicle (m^3/load)
9. Please state the number of deliveries per week that you can achieve.
10. Please state your discharge method(s). Tipper? Elevator? Pneumatic? Other?
11. Please state your normal delay between placement of order by the customer and delivery to site.
12. Please state how many m^3 of chip you are able to store at your depot in a “ready to use” condition. (i.e graded and of at the specified moisture content.)
13. Ordinarily, the hospital will prefer to accept deliveries during normal working hours. It may (in unusual circumstances) be necessary for a load or loads to be delivered outside of those hours. Please confirm that such occasional deliveries will be possible without penalty.
14. The hospital wishes to purchase energy, not fuel. An unfortunate aspect of wood fuel is that the energy content can vary considerably according to the moisture content. An

alternate method of purchase would be to purchase by the GJ, (again subject to a maximum moisture content of 50%).

15. The hospital will be willing to enter into a long term fixed cost supply contract for chip. Can you please provide the following prices for chip, delivered to the Hillmorton site.

	3 years	5 years
Chip $$/tonne to S50, 40% moisture		
Energy $$/GJ to S50, max 50% moisture content.		

2. Chip Supply Responses

2.1 City Firewood

Good Morning Brian,

I would like to give you a guideline as to how we are able to address the supply of wood chip for Hillmorton Hospital set out on your Questionnaire.

1/& 2/Comfortable with that sort of quantity.

3/Our spec's will be a lot tighter than the European standards. S50 would be chip ranging from 30-50mm nothing much either side of that. Also can blend 20-30mm,12-20mm and 5-12mm if required. Sub 5mm is used in our vortex burners.

4/& 5/To supply chip at that moisture content would be seasoned logs and if necessary dry logs in our kiln if they get to wet in the winter months. Also mixed with our firewood waste (hogged)this is either kiln dried or from seasoned firewood.

6/ Would prefer to supply chip that is dried to a lower moisture through our fluid bed dryer at about 17GJ/tonne.

7/ Several samples from each delivery can be tested on an oven dried basis each day.

8/ Chip liner with trailer at 100m3

9/The total amount if necessary.

10/ In this case tipper would be more suitable.

11/ One day.

12/ Will gear up to suit, at least one week supply.

13/ Will be possible, but we are open 6 days.

14/ GJ is fine.

All our chip is well processed forestry based material which is chipped and/or hammer-hog fuel, designed to flow well and be able to be used in conventional coal boiler systems. This enables a wider range of boilers to be used. Please note that tests done at Cashmere high in a Taymac 750kw boiler showed our dry chip to have slightly less PM10 and TSP than wood pellets in back to back tests.

Pricing is yet to be fully established but for fuel around 12GJ/tonne around$100-$110 and 17GJ/tonne around $200-$250

You are welcome to arrange a visit to view progress

John Harris

2.2 Crusaders Garden Makers

Hi Brian, thanks for the email please find my response below

5 the raw wood product is first ground to a minus 100mm in a tub grinder type machine and the minus 12mm is screened out to lessen the chance of it composting, this product is then windrowed for approx 12 months to get a dry product this product is then reprocessed through the finishing plant and the chip is then stored under cover until delivered

6 have been able to get to 30% without much bother

7 we have had our product tested by bucket testers as supplied by living energy or random samples have been sent to the lab for testing by Octa

8 flexible here as the delivery address is close to our processing facility, can deliver up to 100 cubic metres per load if you can handle it

9 as many as you require

10 tippers

11 one hour

12 2000 plus metres of finished chip and approx 5000 tonnes of the raw product

13 we are able to deliver seven days a week

14 I am happy to sell fuel at either a tonne rate or GJ rate

Price for tonne rate to S50 40% moisture $102.00 per tonne delivered, happy to offer this rate for five years with increases annually for inflation

Feel free to contact me to discuss further

Regards

Brian Cribb

0274352231

3. Oil Fuel Specification

2. Physical Description/Properties

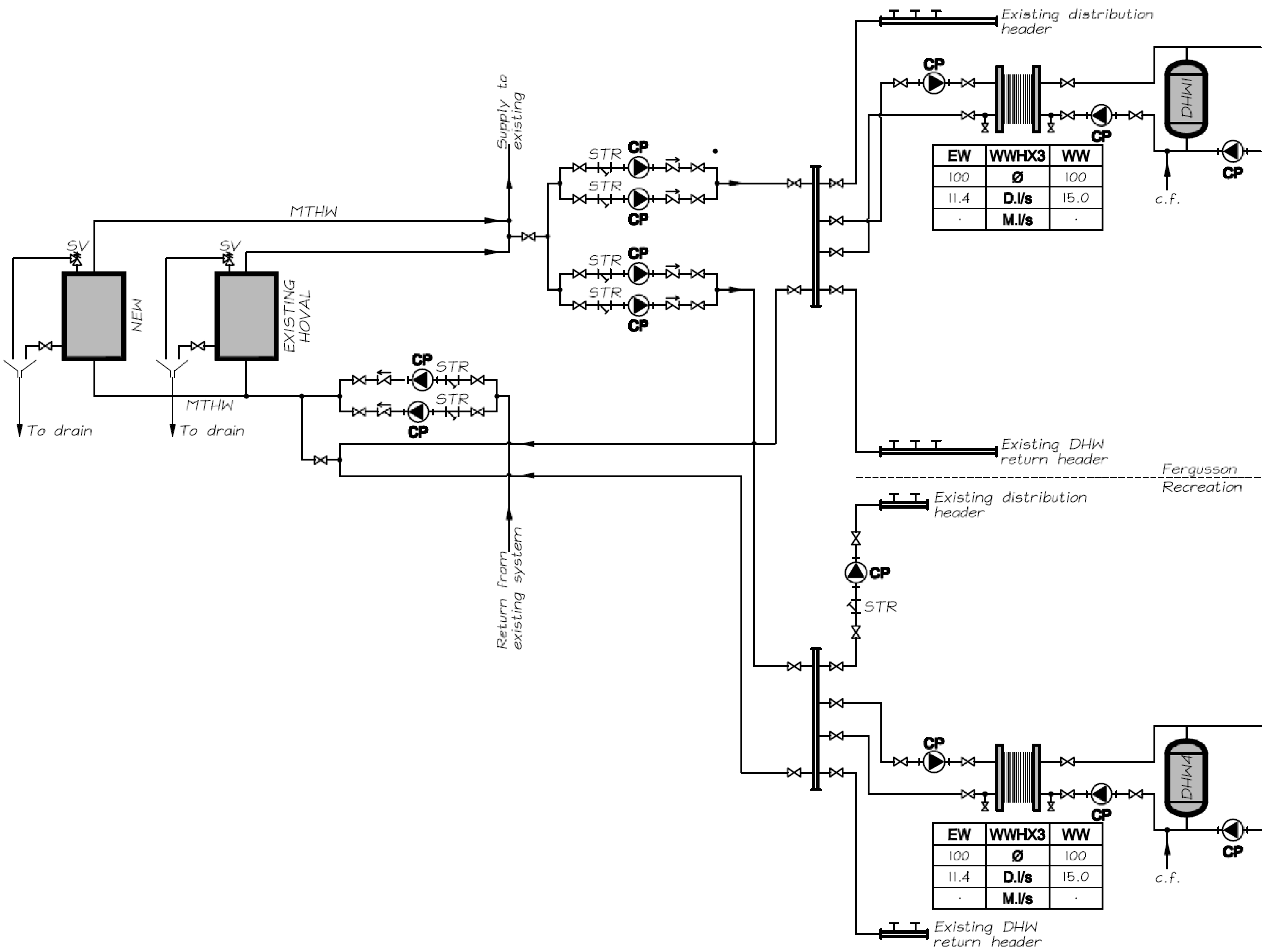
Typical properties:

Description	Typical	Maximum	Method
Form	Liquid		
Colour	Black		
Odour	Oily/oxidised		
Boiling point	98%>250°C		
Flash point	>90 °C	(min) >60°C	ISO/DIN 3679
Gross Calorific Value (MJ/kg)	44		ISO 1928
Cetane number	>51		ASTM D6890
Lead:	<25 ppm	<100 ppm	ICP
Arsenic	<1 ppm	<5 ppm	ICP
Cadmium	<2 ppm	<2 ppm	ICP
Chromium	<2 ppm	<10 ppm	ICP
Copper	<30 ppm	<100 ppm	ICP
Total halogens	<500 ppm	<1,000 ppm	
Polychlorinated biphenyls	Not detectible	Not detectible	

Description	Typical	Maximum	Method
Sulphur	5000ppm (0.5% by weight)		
Water content	<3%		
Ash	0.7%		
Viscosity @ 40°C	40 mm^2/s		EN ISO 3104
Density @ 15°C	900 kg/m^3		ASTM D 4052
Vapour density	> air		

4. Wood Chip Specification

5. Boiler and Pipework Schematic



6. Contractor Estimates