



MWH

BUILDING A BETTER WORLD



**Canterbury District Health Board
Christchurch Hospital Boilerhouse
Wood Firing Feasibility Report
Part 2**

Prepared for EECA

FEBRUARY 2009

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QUALITY ASSURANCE STATEMENT

PROJECT MANAGER	REVIEWED BY
Peter Watson	Aaron Drake
PREPARED BY	APPROVED FOR ISSUE BY
Peter Watson	Peter Watson

CHRISTCHURCH

Tower 2, Deans Park, 7 Deans Avenue, Addington, PO Box 13-249, Christchurch 8141, New Zealand
P + 64-3-366 7449, F + 64-3-366 7780

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1 Executive Summary

1.1 Introduction

The purpose of this report is to establish the feasibility of using wood as a heating fuel in boilers at Christchurch Hospital. It evaluates the feasibility of converting one or both of the proposed coal boilers to wood fuels or installing purpose-built biomass boilers instead of or in combination with the proposed coal boilers. It also evaluates the supply and availability of wood fuel for Christchurch Hospital.

Preliminary work has been carried out to replace the existing boilers (with coal boilers) at Christchurch Hospital. This established the overall requirements, boiler capacity and basic configuration, ancillary services and building services requirements. As part of that work, the basic design requirement was do nothing that would prevent the future use of other readily available coals and wood. This report builds on this work but investigates the requirements for a wood conversion project to be carried out now.

The existing boilers are approximately 42 years old. While they have served the hospital well, they are due for replacement for the following reasons:

- They cannot meet the requirements that are needed to gain a renewal of the Resource Consent for emissions.
- The boilers have insufficient capacity to meet the future growth of the hospital site.
- They require full time manning and the consequential costs.
- Newer boilers are more efficient.

The boilerhouse is critical to the operation at Christchurch Hospital. Even short interruptions can cause major problems. Some of the systems have inertia or storage such as domestic hot water heating systems and radiator based space heating systems.

1.2 Overall Summary

- Wood firing of the boilers at Christchurch Hospital is possible and practical.
- Matching the existing level of on-site security of steam supply is possible and practical.
- Matching the security of off-site supply is more difficult as it involves external organisations. However, a number of contractual requirements can be included in a woodchip supply contract to minimise the effect of equipment failures or financial problems.
- Ultimately a conversion back to coal is always possible.
- The cramped site means that there are very few options, if any, on plant layout. Thus the detail present in this report is necessary to demonstrate a workable solution.

1.3 Wood Supply Conditions

- The current market price for wood pellets makes them uneconomic. In addition, it is expected that the relatively young market and limited number of suppliers would concern the CDHB.
- Payment should be based on the energy content in the fuel with a small reduction in price for increasing moisture content (to reflect the increasing handling and combustion costs associated with an increasing mass of fuel).
- There are a number of contractual conditions to impose on a woodchip supply contract to help ensure a continuity of supply.

1.4 Wood Handling Systems and Boilers

- The woodchip reception facility must be capable of receiving truck and trailer units to minimise the transport costs (and diesel consumption). This corresponds to a nominal delivery volume of 60 m³.
- The extremely cramped site means that there is only one location for the wood reception.
- The existing coal hoppers are unsuitable for woodchip storage due to their shape and have insufficient volume to maintain the current level of fuel storage. Therefore new storage silos are required.
- These silos need to be located adjacent to Antigua Street. There is no other location on site that has sufficient space, can be constructed and provides future flexibility.
- This silo location requires the demolition and rebuilding of a 260 m² portion of the two level building currently occupying this location. The building would be rebuilt as a single level building with the silos on the roof.
- This 130 m² loss of building space would have to be provided elsewhere on site. A cost to provide a new building has been included in the capital cost estimates.
- The basic boiler construction suitable for wood firing has already been allowed for in the boiler replacement project. However, there are some changes to the stokers, combustion fans and control to make them suitable for wood from the start.

1.5 Capital Costs and Operating Costs

- The estimated capital cost is \$5.6M excluding GST and is in 2008 dollars. An inflation allowance needs to be added as some of the work will occur in 2009 and 2010. This cost includes all engineering fees and a 10% contingency. No internal CDHB costs have been included.
- The cost to re-accommodate the current occupants of the building adjoining the boilerhouse (facing Antigua Street) is approximately \$870,000. This includes permanent new accommodation elsewhere on site for some of the occupants and functions, temporary accommodation for those returning to the new building. Obviously, this is a cost item that warrants further discussion internally within the CDHB.
- The estimated woodchip consumption will be approximately 10-11,000 T/yr rising to 12-13,000T/yr in the future based on the expected hospital growth. Note this is based on typical annual weather patterns. The cost of this fuel and a market study is the subject of a separate investigation. Hence it is reported separately.
- The estimated annual additional operating costs, excluding fuel, for using woodchips instead of coal is \$39,000. This covers maintenance on additional plant and equipment and additional staff monitoring.

1.6 Decisions Needed from the CDHB

- The CDHB need to evaluate this technical solution and confirm that it provides an acceptable level of security for the hospital steam supply.
- If so, and an acceptable supply of wood can be obtained at an economic price, then financial approval should be sought.
- Once gained, an early start on the detailed engineering layout to finalise vehicle paths and council requirements. This is needed to obtain a firm tender price the project.

2 Introduction

2.1 Background

The purpose of this report is to establish the feasibility of using wood as a heating fuel in boilers at Christchurch Hospital. It evaluates the feasibility of converting one or both of the proposed coal boilers to wood fuels or installing purpose-built biomass boilers instead of or in combination with the proposed coal boilers. It also evaluates the supply and availability of wood fuel for Christchurch Hospital.

Preliminary work has been carried out to replace the boilers (with coal boilers) at Christchurch Hospital. This established the overall requirements, boiler capacity and basic configuration, ancillary services and building services requirements. As part of that work, the basic design requirement was to do nothing that would prevent the future use of other readily available coals and wood. This report builds on this work but investigates the requirements for a wood conversion project to be carried out now.

The existing boilers are approximately 42 years old. While they have served the hospital well, they are due for replacement for the following reasons:

- They cannot meet the requirements that are needed to gain a renewal of the Resource Consent for emissions.
- The boiler outputs have been reduced from their nameplate ratings to reduce the backend steel to acceptable levels. As a consequence they have insufficient capacity to meet the future growth of the hospital site.
- They require full time manning and the consequential costs.
- Newer boilers are more efficient.

2.2 Layout of this Report

Section 3	Discusses the key requirements and discusses the criticality of the boilerhouse to the operation of the hospital.
Section 4	Presents the basic boilerhouse parameters and the current and future steam loads.
Section 5	Describes the conditions required of the wood fuel.
Section 6	Describes the wood reception and handling systems
Section 7	Describes the boiler aspects (combustion, ash handling and ancillary services).
Section 8	Discusses the necessary installation sequence.
Section 9	Presents a project timetable.
Section 10	Presents the capital and operating costs estimates.
Section 11	Summarises the findings, makes recommendations on the boiler configuration and identifies decisions that need to be made by the CDHB.

3 Key Requirements

3.1 Key Outcomes of This Project

To quote from the MWH “Concept Design Report” for the Boiler Replacement Project:

The key outcomes of this project, as given in the project brief and at various project meetings are:

- *Maintain a steam supply to the hospital at all times during the implementation of this project.*
- *Provide a robust and tolerant steam supply to the hospital that at least matches the past performance of the existing system.*
- *The new boilerhouse is to have a life of 35 years.*
- *Provide a cost effective level of future-proofing in the boilerhouse.*
- *Be able to meet the medium term steam load increases. Have a development strategy to meet the longer term steam load increases.*
- *Be able to handle and burn a range of coal types.*
- *Minimise capital and operating costs.*
- *The new boilerhouse is to be an “Unattended” boilerhouse as defined in the OSH Code of Practice for the operation of boilers. This will reduce the current manning requirements and hence operating costs.*
- *The current Resource Consent for emissions from the boilerhouse is to be renewed.*
- *The Resource Consent conditions are to be optimal balance between minimising capital costs, minimising operating costs, minimising emissions, maximising the duration of the Resource Consent and maximising operational flexibility and fuel choice.*
- *Manage the operational risks and Health & Safety risks in the upgraded boilerhouse.*

3.2 Critical Nature of the Steam System

The boilerhouse is critical to the operation at Christchurch Hospital. Even short interruptions can cause major problems. Some of the systems have inertia or storage such as domestic hot water heating systems and radiator based space heating systems.

However there are a number of systems that are immediately affected by a steam interruption with a significant impact on the operation of the hospital. The main ones are:

Figure 3.1 Effect of Loss of Steam Supply on Hospital Operations

System	Consequence of Loss of Steam	Type of Consequence
Heating water used to heat the ventilation systems for operating theatres. Affects heating in winter and reheating in summer during dehumidification.	Stopping of current operations. Cancellation of upcoming operations.	Health risk and major financial cost.
Humidification systems used in ventilation systems for operating theatres. Generally only used in winter.	Stopping of current operations. Cancellation of upcoming operations.	Health risk and major financial cost.
Sterilisers	Sterilising needs to be repeated. On going work must be stopped.	Financial risk. Potential health risk with a prolonged outage.
Kitchen - cooking	Cooking cannot be completed. Food must be discarded.	Financial risk and potential health risk.
Kitchen - dishwashing	Dishwashing cannot be completed. Handwashing is not a substitute for machine washing.	Financial risk and potential health risk.

Christchurch Hospital is the main public hospital in Christchurch with a large number of operating theatres and the main Accident and Emergency Department. It is not possible to divert patients to other facilities. In addition any cancelled operation involves costs from a large number of staff members. Hence a single cancelled operation involves a large cost to the CDHB.

The boilerhouse and steam system must be a robust design. The system must be capable of coping with the following scenarios:

- A short term interruption to the steam supply.
- A prolonged outage of any one boiler or ancillary system in the boilerhouse.
- Have sufficient fuel storage to cope with adverse weather conditions cause problems with fuel deliveries.
- Tolerant to variable quality fuel supplies. This could be caused by either out-of-specification fuel being supplied, or by the fuel supplier being unable to supply the normal fuel. The latter could be caused by equipment problems, would require obtaining fuel from another supplier or source.

3.3 Staffing Requirements

Currently the boilerhouse has continuous staffing by a qualified boilerman. The boiler replacement project aims to upgrade the boilers to "Unattended" status. Basically this means that a trained person checks on the boilerhouse once per day. The boiler system will run, shutdown and start automatically as required. In the event of a problem, the control system automatically contacts the Shift Engineer or the On-Call person. In the meantime the control system has shutdown the problem systems and started a backup system if appropriate.

The implication is that there will be nobody on site permanently to attend or to operate the fuel reception, handling and storage system. The existing coal system is mechanically quite reliable. As part of the boiler replacement project, more instrumentation would be added to monitor the system. The coal truck driver would unload his truck then press a button to start the coal bucket elevator to load the coal into the overhead hoppers. The control system would know the current hopper levels and which boilers were running and hence can decide the best hopper to fill.

The requirement is exactly the same for a wood handling system. The delivery truck driver will unload his vehicle and start the handling system which must operate automatically and shutdown once the work is complete. The system must be fully automatic and fault tolerant. Typical issues with wood handling systems are:

- Wet wood causing wood to adhere to hopper surfaces
- Wet wood or larger than specification pieces causing bridging in hoppers.
- Larger than specification pieces jamming the system or breaking causing bridging in hoppers.

This places quite a restriction of the quality of the wood being supplied. The anticipated requirements are discussed further in Section 5 Fuel Conditions.

4 Boilerhouse Parameters

4.1 General

This section summarises the main operating parameters and steam loads at the boilerhouse. Much of the information presented here is a summary of the information derived in the MWH report for the CDHB "Boiler Replacement Concept Design Report" dated December 2008.

4.2 Present and Future Steam Loads

4.2.1 Current Steam Loads

The table below summarises the coal deliveries to the boilerhouse and the total measured steam generation by all three boilers. Note that the steam flows are measured individually on each boiler by orifice plates. Therefore the steam flow readings at low steam flows is likely to be less accurate.

The coal consumption by the boilers is not measured in real-time. As the coal storage on site is relatively small in relation to the monthly coal consumption, the coal deliveries can be used to obtain an overall check on the boiler steam flow meters.

Table 4-1 Monthly Coal Deliveries, Steam Production and Apparent Boiler Efficiency

Month	Coal Deliveries (Tonnes)	Average Coal Energy (MW)	Total Steam Production (Tonne)	Average Steam Load (MW)	Apparent Boiler Efficiency
July 2007	890	8.05	6,090	5.63	70%
August 2007	856	7.50	5,670	5.07	68%
September 2007	657	5.94	4,910	4.54	76%
October 2007	713	6.24	4,740	4.24	68%
November 2007	580	5.25	3,970	3.67	70%
December 2007	554	5.02	3,560	3.29	66%
January 2008	491	4.44	3,610	3.34	75%
February 2008	497	4.35	3,580	3.20	74%
March 2008	510	4.46	4,040	3.61	81%
April 2008	638	5.58	4,310	3.86	69%
May 2008	787	7.12	5,790	5.35	75%
June 2008	759	6.65	5,850	5.23	79%
Total	7,932 Tonne/yr	51,700 MWh/yr	56,120 Tonne/yr	37,500 MWh	72.3% Annual

The ratio of coal delivered to steam production gives an annual overall boiler efficiency of 72.3%. This is slightly higher than expected for boilers of this age, technology and level of control system. It is more likely that an annual efficiency of 65-70% occurs in practice. The steam production figures include the steam used to preheat the feedwater. This steam is estimated to be 4.6% of the annual boiler steam production. Therefore the overall annual boilerhouse efficiency, when measured "at the boilerhouse wall", is 67.7%. In the absence of any accurate information to the contrary, the steam meter readings are assumed to be correct and a true representation of the current steam loads at the boilerhouse.

Thus the current delivered energy requirement from the boilerhouse is 37,500 MWh/yr

4.2.2 Future Steam Loads

A series of growth scenarios have been modelled for the site served by the boilerhouse. These cover the three factors that affect the future steam load:

- Identification of the total building stock increase.
- Identification of an appropriate peak energy consumption for these additional buildings.
- Identification of the effect of future energy saving measures.

The result is that a peak steam load increase of 3.6MW is expected and an annual steam load increase of 10,000MWh is expected in the next 20 years. This is tabulated below:

Table 4-2 Expected Steam Load Increases

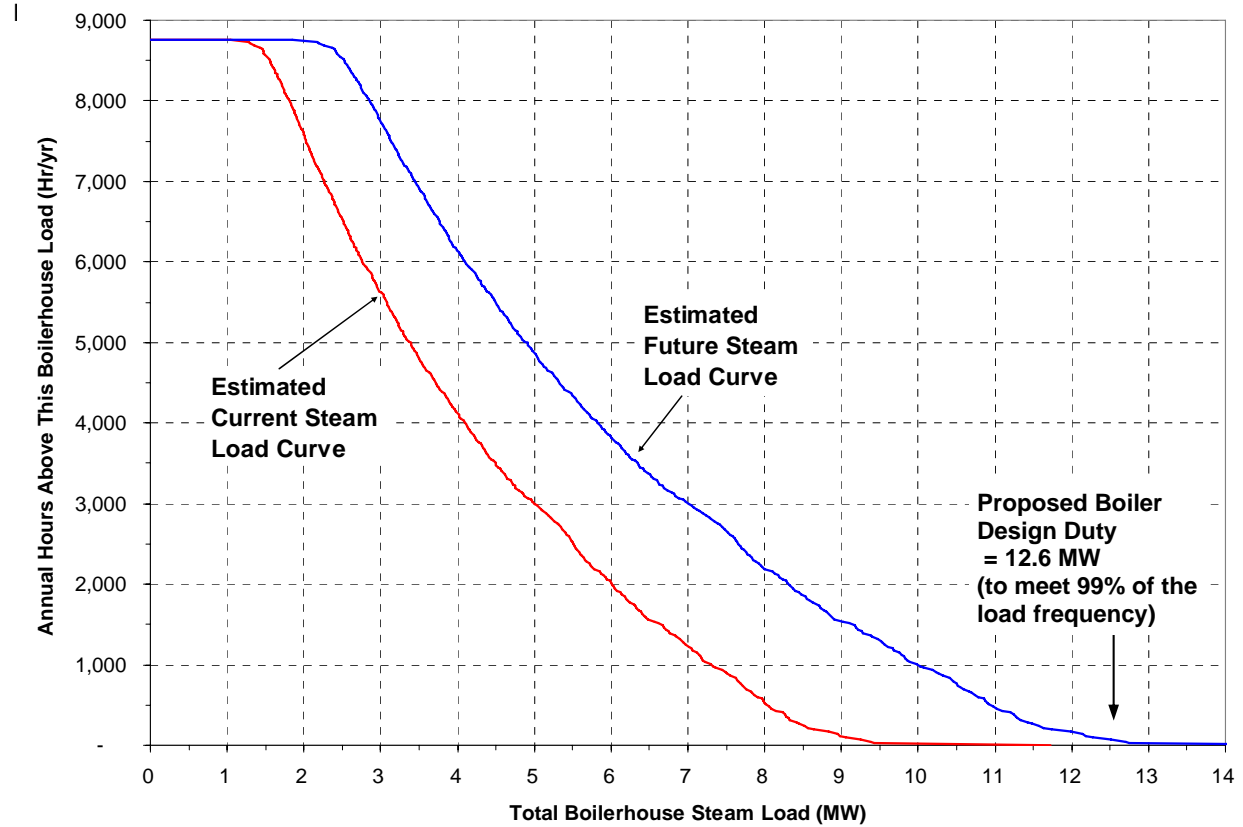
Year	Annual Energy Production		Peak Steam Demand	
	MWh/yr	Increase	MW	Increase
Year 0	37,500	0%	9.0	0%
Year 1	37,500	0%	9.0	0%
Year 2	37,800	1%	9.1	1%
Year 3	38,000	1%	9.2	2%
Year 4	38,300	2%	9.3	3%
Year 5	38,500	3%	9.4	4%
Year 6	38,800	3%	9.5	5%
Year 7	40,400	8%	10.1	12%
Year 8	43,800	17%	11.3	25%
Year 9	43,800	17%	11.3	25%
Year 10	44,100	18%	11.4	26%
Year 11	44,400	18%	11.5	28%
Year 12	44,700	19%	11.6	29%
Year 13	45,100	20%	11.7	30%
Year 14	45,400	21%	11.8	32%
Year 15	45,700	22%	12.0	33%
Year 16	46,100	23%	12.1	34%
Year 17	46,400	24%	12.2	36%
Year 18	46,700	25%	12.3	37%
Year 19	47,100	26%	12.4	38%
Year 20	47,500	26%	12.6	40%

Thus the current peak steam load increases from 9MW to 12.6MW. This load is only exceeded 1% of the time. Allowing a small margin above this gives a proposed operational boiler capacity of 14 MW.

The reason for the peak steam demand increasing at a greater rate than the annual energy requirements is the increased level of insulation provided in new buildings. This means that the internal heat gains from lights and appliances provides a greater portion of the heat demand.

The estimated boilerhouse load duration curve is shown below.

Figure 4.1 Estimated Current and Future Steam Load Duration Curve



4.3 Boiler Configuration, Standby Capacity & Summary of Energy Requirements

The previous section gave the peak load expected to be seen by the boilers as 12.6 MW. The logical boiler configuration is therefore two 7MW boilers running in winter. A third, identically sized boiler would be provided for backup. The two main boilers would be solid fuel fired units. The backup boiler is proposed to be diesel fired because the capital savings far outweigh the expected running costs.

A conservative estimate of the annual diesel consumption is that the diesel boiler will provide 3% of the total steam production. Thus the overall steam energy required from the solid fuel fired boilers rises from the current level of 36,400 MWh/yr to 46,100 MWh/yr.

Table 4-3 Expected Steam Load Requirements

Year	Annual Steam Energy Production (MWh/yr)	Provided by the Diesel Boiler (MWh/yr)	Provided by the Solid Fuel Boilers (MWh/yr)
Year 0	37,500	1,100	36,400
Year 1	37,500	1,100	36,400
Year 2	37,800	1,100	36,700
Year 3	38,000	1,100	36,900
Year 4	38,300	1,100	37,200
Year 5	38,500	1,200	37,300
Year 6	38,800	1,200	37,600
Year 7	40,400	1,200	39,200
Year 8	43,800	1,300	42,500
Year 9	43,800	1,300	42,500
Year 10	44,100	1,300	42,800
Year 11	44,500	1,300	43,200
Year 12	44,800	1,300	43,500
Year 13	45,100	1,400	43,700
Year 14	45,400	1,400	44,000
Year 15	45,800	1,400	44,400
Year 16	46,100	1,400	44,700
Year 17	46,400	1,400	45,000
Year 18	46,800	1,400	45,400
Year 19	47,100	1,400	45,700
Year 20	47,500	1,400	46,100

4.4 Coal Currently Used

Currently the boilers operate on a blend of West Coast coal and Canterbury coal. The resultant gross calorific value is 23.5 MJ/kg. For future flexibility, the current CDHB boiler replacement strategy provides a boiler plant capable of burning a range of coals from the current blend to a Southland lignite with a calorific value of 60% of the current blend. This strategy applies to the basic boiler construction and design, but does not extend to enlarging the coal reception, handling and storage systems to cope with the additional volume of coal corresponding to the lower calorific value. To achieve the same energy content with a coal with a calorific value of 60% means that approximately an extra 66% of coal is needed. A change to a coal of this type is not anticipated in the immediate future. However, should a change be required then the work involved will be only additional work to the boilerhouse and no significant remedial work to equipment currently being proposed.

Thus the baseline fuel for comparison with wood firing is the current coal blend at 23.5 MJ/kg at a baseline cost of \$151/tonne.

While the current estimated annual boiler efficiency is 72.3%. A new coal fired boiler is expected to increase this figure by 5%. While the resulting figure of 77.3% seems higher than typical it is the reduction in fuel usage that is important.

Thus a new coal fired boilerhouse is expected to consume 7,400 tonnes of coal costing \$1.197M at the current loads. This rises to 9,400 tonnes and \$1.419M at the end of 20 years growth (in current dollars).

4.5 Fuel Storage Requirements

Currently the boiler provides approximately 60 tonnes of coal storage per boiler in the overhead hoppers and approximately 15 tonnes in the underground reception hopper.

During a typical winters day the average daily boiler load is 7MW. With the future loads this rises to 11MW.

Table 4-4 Existing Coal Storage Coal Provided (In terms of days of peak usage)

Scenario	Peak Daily Steam Demand	Peak Coal Consumption	Overhead Storage Above the Boilers (Both Boilers)	Total On-Site Storage Including the Coal Reception
Current Steam demand	7MW	34 Tonne/day	3.5 days	3.9 days
Expected Future Steam Demand	11 MW	53 Tonne/day	2.3 days	2.5 days

Note that the storage presented above includes the daily load profile. It is not the number of days provided to allow the boilers to run at full capacity.

4.6 Future Cogeneration

The current boiler replacement strategy provides a boilerhouse which is capable of modification to operate a steam turbine. The optimum electrical generation rating is between 800 to 1,000kW. The economic return depends on the prevailing electricity price and the cost of capital. Currently cogeneration provides a reasonable return but is not compelling to provide the CDHB with an obvious decision to proceed. The reason cogeneration is raised is that if a wood conversion proceeds and if the wood is more expensive than coal, it will disadvantage the CDHB and possibly lose a cost saving project.

Based on a 800kW(elect) steam turbine, the additional steam requirements range from 3,500 MWh/yr at the current time to 4,800 MWh/yr at the end of the current growth period.

4.7 Construction Constraints

The existing coal hoppers are not suitable for woodchips. As a rule, hoppers with tapered sides should be avoided due to the risk of the woodchips bridging and not flowing. Almost all woodchip handling systems have flat bottomed silos with an active device to move or agitate the chips. This means that the existing coal hoppers above each boiler are not suitable for reuse. So either the existing hoppers are replaced or a separate system is provided. If the hoppers are replaced then there is a construction period of approximately 4 months when the existing coal boilers cannot operate. On a simple basis this gives a diesel cost of \$1.8M. Deducting the coal that would it replaces gives a net increase in fuel cost of \$1.5M.

This has a number of implications. Obviously this is a large cost that cannot be avoided as the work is required right on top of the existing boilers and there are major health and safety issues with major construction work so close to a steam boiler.

The other risk is that the diesel costs will blow out. It is essential to keep the contractor working to a tight timetable. The consequential costs of being late are far in excess of the contractual damages that would be accepted by a contractor. So on a practical level, a new woodchip silo cannot be built on top of the existing coal hoppers. Therefore the new woodchip silos must be built elsewhere and the coal boilers kept operational during the bulk of the construction work.

5 Fuel Conditions

5.1 General

This section describes the conditions necessary to make an acceptable wood supply to the CDHB. These cover energy content, moisture content, delivery volume, continuity of supply, off site storage, supply system redundancy (extra trucks, extra chippers).

5.2 Wood / Coal Combinations

One of the aims of this investigation is to investigate installing one or more wood fired boilers to either replace or supplement the proposed coal boilers. Therefore one of the options to consider is to have both coal and wood as fuels on site. As part of the design work already carried out on this project, it has been identified that the backup boiler should be diesel to reduce the capital cost requirements and to speed up the response in the event of a total failure of the operational boilers.

Therefore the option to have both coal and wood boilers would therefore have three fuels on site. There are obvious issues over standardisation and commonality issues and staff familiarisation issues. The major problem is that there is simply insufficient space on site to sensibly have both an operational coal and operational wood handling system on site. Note that this is quite different to have both systems installed but needing work to switch fuels. The different physical properties of each fuel make the sharing of a common reception and transport system not practical.

Burning a blend of coal and woodchips presents a series problems that make it impractical on this large scale. Firstly, large scale off-site blending involves additional handling by the fuel supplier, and consequential degradation of the coal pieces. Feeding the fuel into the boiler separately is possible. However as noted above, two fuel handling system will be required. In addition, wood and coal have differing ash fusion temperatures, so ash handling can become problematic if the ratio of one fuel to the other becomes significant. Small blends, either way, are possible. Although taking an overall view, two fuel systems require additional maintenance and operational costs. Hence it should not be considered as a long term solution.

Holding a hopper full of coal as a long term backup fuel is not advisable as the coal dries out and can spontaneously combust. While this can be managed with water sprays, it does present a residual risk.

Overall, an operational mixture of wood and coal on this site is not a practical solution.

5.3 Fuel Forms Considered

The aim of this study is to evaluate the feasibility of wood firing. Therefore one of the first key objectives is to identify forms of the wood fuel. Possible forms are sawdust, chips, pellets, recycled wood. In general terms, any fuel that requires intervention by CDHB staff is not acceptable. This is from a cost aspect and a healthy and safety one. The latter is particularly relevant as blockages in mechanical conveying are the cause of many industrial accidents. In addition all the fuel storage areas are classified as Confined Spaces therefore at least two staff are required to attend to any blockage within a hopper that cannot be cleared from the outside.

Most of these fuels can be discounted immediately. Pellets require a more detailed discussion.

5.3.1 Wood Pellets

Pellets are currently a high profile fuel in residential and small commercial heating applications in New Zealand. Currently they are untested in New Zealand on large scale boiler plants such as the Hospital. The main reason is that pellets are considerably more expensive than coal and woodchips.

The basic parameters of wood pellets are:

Table 5-1 Basic Properties of Wood Pellets (from AS/NZS 4014.6)

Energy Content	18-21 MJ/kg (gross energy content)
Bulk Density	640 kg/m ³ minimum
Moisture Content	4-8 % typical (wet basis)
Ash	Less than 0.5%

Broadly speaking, this is similar to coal at 23.5 MJ/kg (gross) and a bulk density of 750 kg/m³. So from a handling aspect, the two fuels are similar. Thus the existing coal handling system at the hospital can be utilised.

As the energy content is lower and the density is lower, the amount of energy stored on site within the existing overhead and reception hoppers is less. Thus changing to pellets involves a 27% loss in fuel storage (based on energy content). To compensate for this and to maintain the existing storage levels, an additional 50m³ of storage would be required. There are several methods of achieving this. The simplest would be to utilise the existing hopper above the southern most bay in the boilerhouse. This is currently unoccupied but will become a diesel boiler in the future. So this hopper will never be used to feed a boiler. This hopper could be filled from the existing bucket conveyor system. A screw conveyor (or belt conveyor) could be installed to return the pellets to above the coal reception enclosure. They would then drop into the reception hopper in the same manner as the current truck deliveries. From here, it can be transferred to a hopper above an operational boiler in the normal manner.

In New Zealand the market is still relatively new. As there are only a few companies manufacturing wood pellets, there is inevitably a risk of one of more of the manufacturers going out of business. Alternatively a major breakdown in one of the manufacturing sites would cause a major supply issue. Both of these scenarios would be a major concern to the CDHB as the boilers would be customised to run on this specific fuel and it would take time to convert back to coal.

As mentioned above the major issue with wood pellets is the cost. The approximate cost for the large quantities required is expected to be in the order of \$300 /T. In terms of energy content this is 2.3 times the price of coal. Thus, the annual fuel bill for Christchurch Hospital would increase by \$1.6M to \$2.8M. To fund the use of this fuel would require a major diversion of funds currently used for other core healthcare tasks. Therefore this would not be acceptable to the CDHB. Therefore wood pellets are not considered viable.

Figure 5.1 Typical Wood Pellets and Woodchips



5.3.2 Summary

The possible fuels can be summarised below:

Table 5-2 Possible Wood Fuels and Their Suitability

Wood Type	Comments	Acceptable for Chch Hospital?
Sawdust	<ul style="list-style-type: none"> • Difficult to handle if wet (sticks to surfaces and causes bridging in hoppers) • Bulk density is lighter than chips. Therefore a large storage volume is required. • Need to ensure wood is untreated and sawdust does not come from joinery factories to avoid glues and other contaminants. 	No
Woodchips (up to 50x50x6 nominal)	<ul style="list-style-type: none"> • Suitable (with a new reception, handling and storage system as detailed further on in the report) 	Yes
Larger wood pieces	<ul style="list-style-type: none"> • Difficult to handle automatically without jamming • Different sized pieces burn at differing rates. So combustion control is more difficult. 	No
Recycled wood	<ul style="list-style-type: none"> • Need to ensure the wood does not contain treated wood or other contaminants (nails, paint, stones, etc) 	No
Wood Pellets	<ul style="list-style-type: none"> • Much higher cost than other wood fuels and coal. • Limited number of suppliers and manufacturing capacity. • Fuel handling system is similar to coal. • The lower energy content and lower density mean that the on site storage must be increased over coal 	No

Therefore the remainder of the report deals with woodchips as the fuel format.

5.4 Wood Chip Size and Specification

As the biomass industry is quite well developed in Europe, there are a number of standards related to the “quality” of the fuel. As this is a feasibility study only, it is obviously too early to nominate a particular standard. The main point to make is that the CDHB will need a fuel “specification” to ensure that the fuel is uniform from a handling, combustion and ash disposal point of view. Without this additional staff intervention is need to fix blockages or improper combustion.

The implication of a consistent fuel is that there is a quality system needed by the fuel supplier and a system at the hospital to monitor compliance. This all requires additional cost over simply chipping timber to fill a truck and then delivering it.

In Europe the basis woodchip specifications cover the following general aspects (Taken from CEN / TC 335 standards)

- Particle size. Usually expressed as P16, P45, P63, P100, etc to reflect the maximum particle size in mm.
- Maximum fines content. Usually expressed as a maximum percentage of particles less than 3mm across. No dust or wood flour is permitted

- Moisture content. Usually expressed as M20, M30, M40, M55, M65, etc to reflect the maximum moisture content as a wet basis percentage.
- Ash content. Usually expressed as A0.7, A1.5, A3.0, A6.0, A10.0, etc to reflect the maximum ash content as a percentage
- Energy content.

In general these provide consistency for fuel handling systems and combustion. The key factors are discussed below and their influence on the boilerhouse operation.

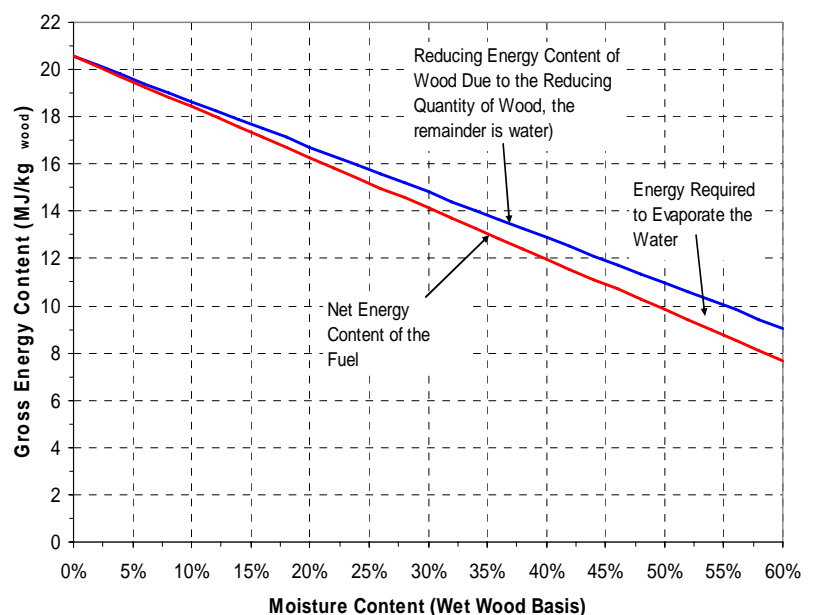
5.5 Moisture Content and Energy Content

The moisture content in wood has a major effect on the net energy content available to be used to obtain useful heat. Typically solid fuel is sold by weight, as the size and shape of the individual chips or pieces affects how well the fuel packs together and hence affects the density and makes a sale basis by volume very difficult.

The water in the wood has two effects; firstly it reduces the amount of wood per tonne of fuel. Secondly the water requires energy to evaporate it. Hence reducing the net energy available. The following table and graph show the effect on the energy content with increasing water content. Note that there are many influences on the energy content such as timber species. So the data should be considered indicative only.

Table 5-3 and Figure 5.2 Indicative Energy Content Variation With Moisture Content

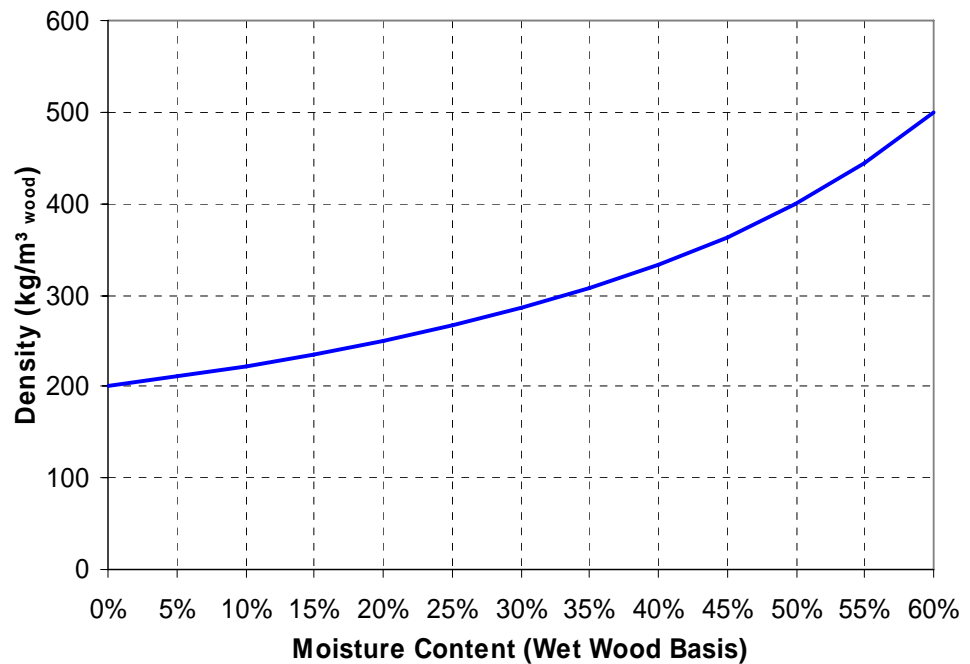
Moisture Content (Wet Wood Basis)	Wood Energy Content (Gross MJ/kg _{total})
0%	20.6
5%	19.5
10%	18.4
15%	17.3
20%	16.3
25%	15.2
30%	14.1
35%	13.1
40%	12.0
45%	10.9
50%	9.8
55%	8.8
60%	7.7



The water content adds weight to the fuel but not volume. So the density changes with moisture content. The effect of this is illustrated below. This obviously affects transport costs and to a much lesser extent operating costs within the boilerhouse. Note that the chip size and agitation affects the way the chips pack together so the table and figures below are indicative only.

Table 5-4 and Figure 5.3 Approximate Bulk Density Variation With Moisture Content

Moisture Content (Wet Wood Basis)	Bulk Density (kg/m ³)
0%	200
5%	211
10%	222
15%	235
20%	250
25%	267
30%	286
35%	308
40%	333
45%	364
50%	400
55%	444
60%	500



5.6 Basis of Sale

From the preceding section it can be seen that the heating value of the wood is significantly degraded with increasing moisture content. So a price agreement based on energy content is essential. The suggested approach is:

- A sample of each truck load is taken (using a 5 litre container say).
- The sample is emptied into a mesh bag. The bag and contents are weighed.
- The bag is placed in a heated cupboard.
- After 24 hours the bag and contents are re-weighed.
- The dry and wet wood weights (excluding the bag) are used to calculate the energy content for that truck load.
- The price paid is on an energy basis (\$/GJ) with a slight price variation downwards with increasing moisture to reflect the increased fan power and handling system power needed to move the increased volume and mass of wood to gain the same energy content.

While this process may seem cumbersome, it can be carried out by the truck driver with spot checks by CDHB staff.

5.7 Continuity of Supply

With the large scale supply of woodchips for heating being a new industry, the CDHB will need to ensure that the wood supply can supply the fuel in the event of foreseeable and reasonable unforeseen situations.

The factors included in a possible supply contract would cover some of the following items:

- At least 7 days quantity of woodchips to be held in off site storage. Currently this coal quantity is held with 25km of the boilerhouse, with flat major roads between.
- In addition, consideration should be given to also specifying a minimum quantity of unchipped wood to be held at the chipping site.
- All woodchip storage must be covered. Wood absorbs moisture more easily than coal.
- At least two trucks capable of delivering the wood must be available.
- At least two chipping machines must be available.
- Ash disposal. Currently the removal of ash is included in the coal supply contract. The inclusion of this requirement gives the supplier a (slight) incentive to minimise quantity of ash. However the main driver is that the CHDB does not incur additional costs through the variable quantity of ash if a third party was involved.

The above items attempt to match the security of the existing supply chain. Before any woodchip contract is let, a wider review of the Christchurch Lifelines project should be undertaken to assess any other issues that may occur during a civil defence emergency.

5.8 Intervention and Assistance by CDHB Staff

One of the drivers for the boiler upgrade project is to reduce the manning levels at the boilerhouse. Therefore the woodchip handling and storage system must be essentially fully automatic and robust. While the ideal situation would be to contract the wood supplier to respond to faults with the system, it is unlikely to be cost effective nor provide an acceptable response time. Therefore irrespective of the contractual arrangements, the operating costs calculated have included an allowance for fault responses by CDHB staff.

6 Wood Reception and Handling System

6.1 General

Woodchips have an energy content that is significantly less than coal on a weight-for-weight basis. This ranges from 85% of the coal energy content for oven dried woodchips to 50% for woodchips containing 40% moisture. Therefore the existing coal reception and storage hoppers cannot match nor provide a similar amount of storage when filled with woodchips. Consequently the on-site storage requirements must be increased.

From section 4.5 Fuel Storage Requirements above, with the future steam loads the existing equipment provides 2.3 peak days storage above the boilers and a total of 2.5 days storage including the coal reception hopper.

Therefore these figures should be matched (approximately) when converting to wood.

For a given volume, coal has 4.4 times the energy content than woodchips. This means that 4.4 times amount of on site storage is required.

The approach to sizing the system starts with the size of the delivery truck. This determines the reception hopper capacity. The next step determines the remaining storage needed. This in turn governs where the storage can be located on site and hence what type of conveying system is needed.

The following sections describe these steps in more detail.

As described earlier, the energy content and density vary with moisture content. As the time of expected maximum moisture content, matches the time of maximum heating demand, a slightly pessimistic moisture content of 40% as been assumed in the sizing of the woodchip handling system. From a materials handling aspect the volumetric flow requirement is approximately constant. However as the water content increases the mass flow rate increases. The mass flow rate is what determines the size of the motors and the system strength. Hence a high moisture woodchip is used in sizing the handling system, but not necessarily the annual fuel cost.

Therefore the overall demand on a peak day with the future steam loads is 320 m³/day. Note that at 10% moisture the corresponding figure is 310 m³/day.

6.2 Woodchip Reception Capacity

6.2.1 Delivery Truck

The maximum allowable vehicle weights and dimensions for standard vehicles mean that trucks transport woodchips are volume limited rather than weight limited. The practical maximum for a single truck unit is 30m³. A truck trailer unit doubles this to 60 m³. At 40% moisture content (333 kg/m³) this relates to 20 Tonne load. At 10% moisture content this relates to a 13 Tonne load.

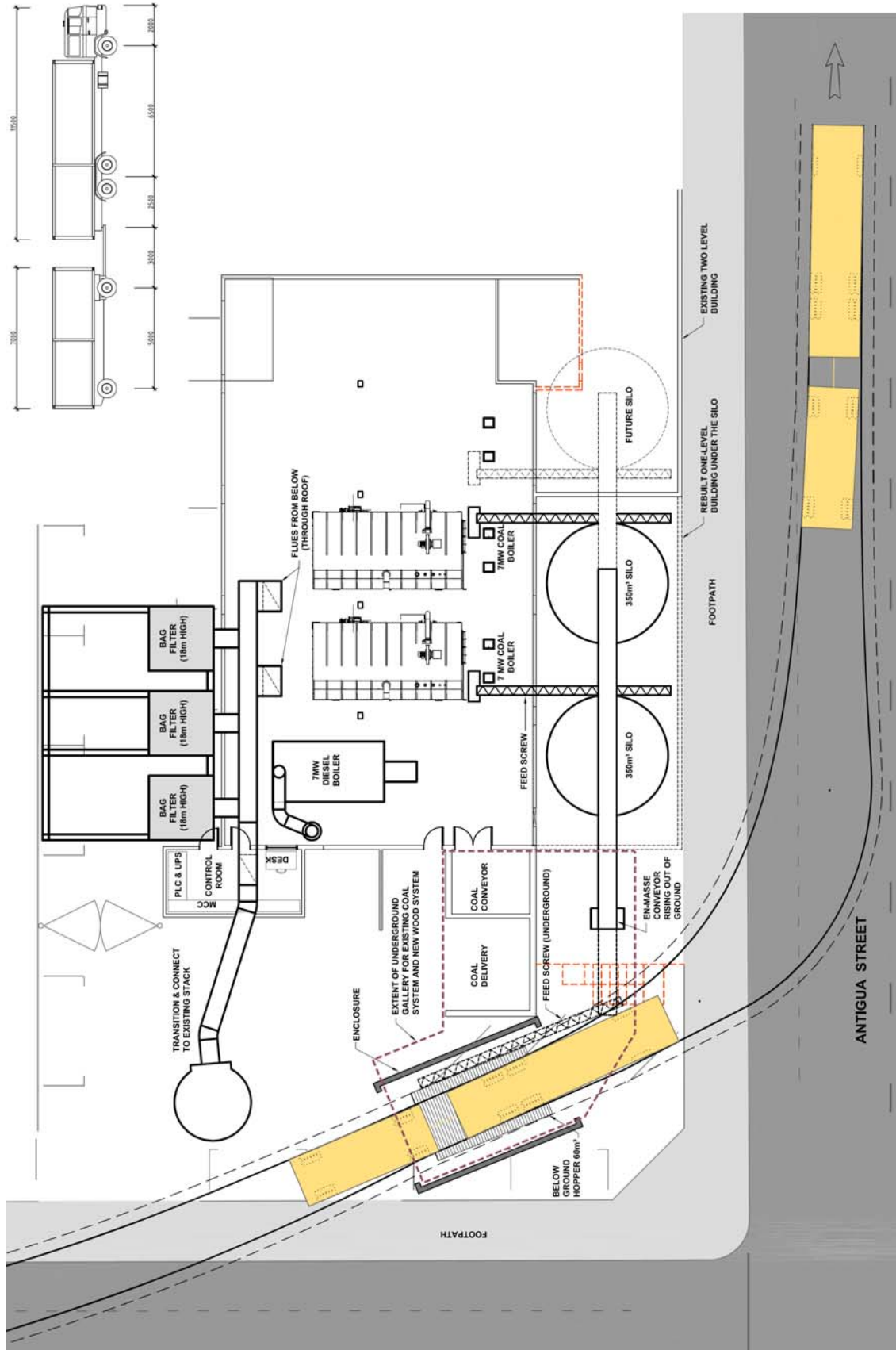
To minimise transport costs, a woodchip reception facility is proposed that can accept 60 m³ vehicles is proposed. In practical terms, this makes little cost or practical difference over 30m³.

Based on the expected future steam loads, 5.2 truck and trailer deliveries are required per day at peak times. If single truck units (without trailers) are used then 10.5 deliveries are need at peak times in winter.

Assuming the fuel suppliers operate on a 10 hour day then a truck and trailer unit will arrive every 2 hours. Thus the woodchip handling system must be able to move 60 m³ in say, 1 ½ hours. This only gives a 30 minute margin but this reasonable as this frequency only occurs at peak times. Thus the woodchip handling system needs a minimum capacity of 40 m³/h (13 T/hr).

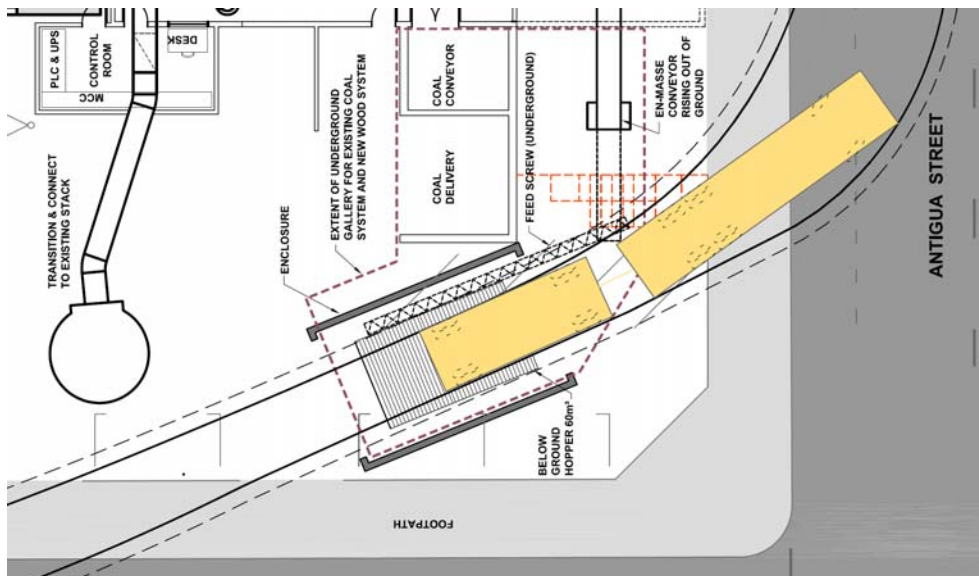
As described in section 4.7 Construction Constraints, the existing coal hoppers must remain operational during construction. Therefore the logical extension to this is that if the coal handling system remains, then the boilerhouse could be converted back to coal (at a cost) if there was a woodchip supply issue. This is the basic assumption to the detailed layout of the woodchip reception area.

The woodchip vehicle size means that a completely new drive through arrangement is needed. This is shown on Figure 6.1 on the following page. This diagram shows the complete proposed installation.

Figure 6.1 General Layout of Woodchip Handling and Storage System


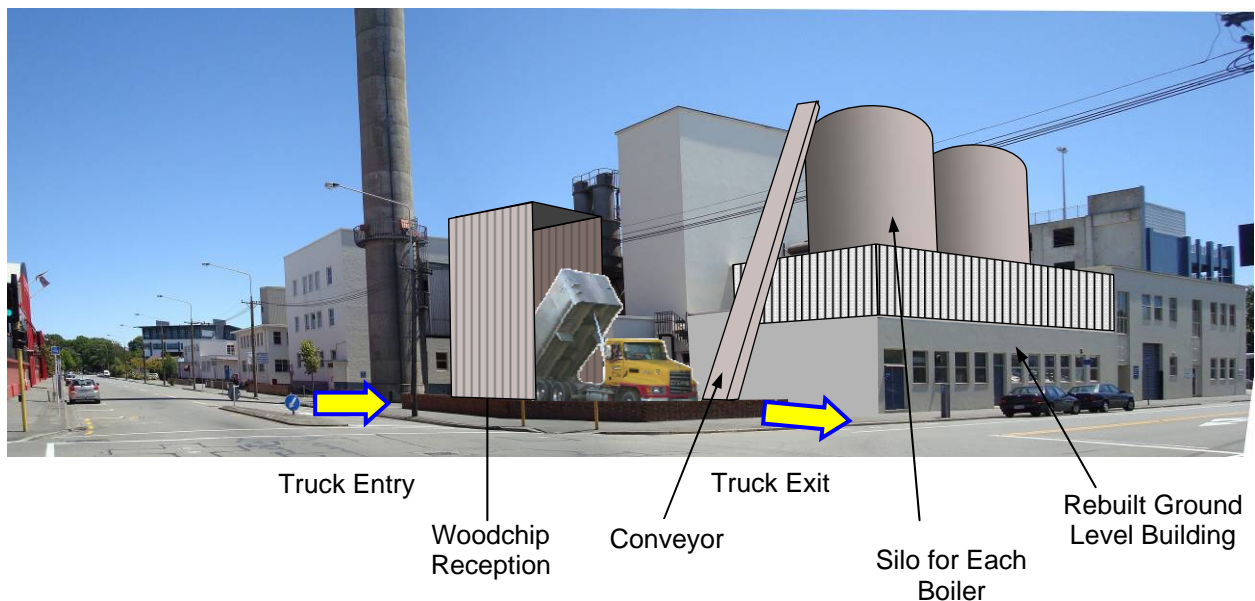
The truck path is very constrained and is certainly not ideal. Figure 6.1 on the previous page shows the delivery truck and trailer unit in the tipping location to empty the truck (over the trailer drawbar). The partial plan below shows the vehicle location when the trailer is tipped. While this theoretically shows the truck in the roadway. It is believed that during a more detailed investigation this could be pulled back into the parking zone of the roadway. This is still potentially an issue with the Council as the regular position for the truck emptying blocks the footpath. While the duration is short, it is still the normal mode of operation. Emptying a truck without a trailer is not an issue as it is entirely contained within CDHB property.

Figure 6.2 Partial Layout Plan with Vehicle Emptying the Trailer



The illustration below shows the scale of the system. The following sections discuss the various components of the system.

Figure 6.3 Indicative Massing of Woodchip Reception and Storage Silos



6.3 Woodchip Reception

The reception facility will comprise the following components:

- Ground level drive through for the truck and trailer. The entry and exit streets are so close that any change in elevation is not practical.
- The hopper will be covered on either side and roofed over to minimise rain ingress. The structure will be nominally 10 m high to allow the truck and trailer unit to fully tip. At either end, there would be plastic curtains down to say 5m high. Below this would be security gates. These would be motorised and be controlled by the truck driver via a remote control.
- Underground hopper with at least 60m³ usable capacity (to match the delivery of one truck and trailer unit). Note that a small amount of woodchip piling above ground level is possible if the hopper has not completely removed the previous truck load.
- A walking or push/pull floor feeds the woodchips to one side.
- From here a lateral screwfeeder feeds the woodchips to a single point.
- The woodchips then drop onto a conveyor system as described further on in this report.
- The depth of excavation must be minimised as the ground conditions are not ideal and the close proximity of both the 55m high stack and the boilerhouse. This means that the underground hopper will be essentially rectangular and only 2 m deep. Allowing for the space underneath for the walking floor, screw conveyor and woodchip conveyor means that the floor level of this underground area is approximately 3.0m below ground level around the main hopper and 4.5m deep at the end where the screw conveyor feeds onto the conveyor.

As a final comment, it is possible to swap the truck entry and exit points, in other words there is no reason why trucks could not drive through the reception area from Antigua Street and leave onto St Asaph Street. Currently there does not seem to be any advantage as the vehicle will have to cross to and from the opposite side of the road to enter and leave. This presents more of a traffic risk that simply entering and leaving on the same side of the road. However the option does exist to swap the truck direction as needed.

6.4 Locations for On-Site Woodchip Storage

Various locations have been investigated for the on-site woodchip storage. To match the existing coal storage, the volume of woodchip storage required is 770-800 m³. This range depends on the moisture content of the chips. Various locations for this storage have been considered and are discussed below.

The area in front of the boilerhouse, fronting onto St Asaph Street, is fully occupied with the wood reception, ash removal and main boilerhouse stack. Therefore this location is not available.

The alleyway to the west of the boilerhouse is planned to house the bag filters. These are mounted on a steel frame to provide approximately 6m clearance under for service access to the boilerhouse. In addition, the steel framework will be used to seismically strengthen the boilerhouse. In the future a fourth boiler could be installed in the boilerhouse. This would require an additional bag filter. This means that there is insufficient space for all the bag filters and the woodchip silos here. The proximity of the boilerhouse chimney means that there is no other sensible location for the bagfilters. Therefore the woodchips cannot be located above the alleyway. If space was available, the storage silos would present a risk to the adjacent building, even though both will have fire protection systems. The silo will have to be higher than the adjacent building to ensure the explosion relief vents in the top do not cause a risk to the

building. Finally, there would be a major loss of amenity in that office building as it would effectively block all natural light along the east wall.

Building the silos on top of the boilerhouse roof directly above the boilers would present a major health and safety risk, no matter how much protective scaffolding is place above the roof. The individual components being craned in will weigh up to 15 tonnes.

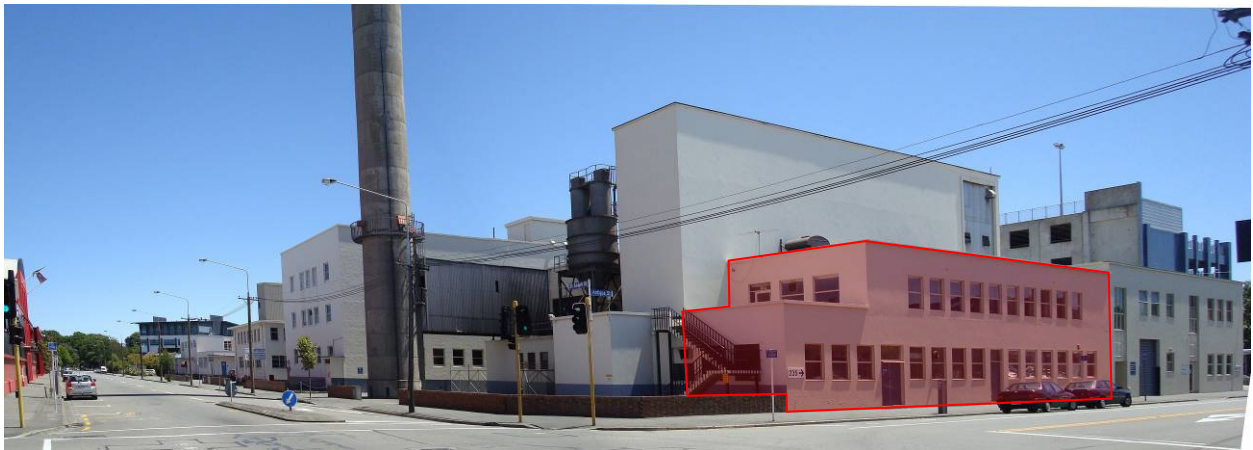
The final location possible is above the existing two storey building facing Antigua St. Currently this houses Engineering and Maintenance staff. The first approach would be to build on top of the building. However the relative levels of the coal hoppers and roof mean that the coal screws would have to run through the first floor of the existing building. This makes the first floor mostly unusable. In addition, the support work needed to support the silos and brace them seismically means that major portions of the building would be cut away. Currently the building does not have sufficient strength to meet the earthquake requirements for a boilerhouse. So it does not have any spare capacity to support the silos.

The conclusion is that the existing building needs to be demolished and rebuilt as a single level building with purpose designed supports for the wood silo. The rebuilt ground floor can be occupied by the current staff. However, there is loss floor space equal to the second level. This space would need to be provided elsewhere on site.

6.5 Description of Woodchip Storage

The first step is the demolition of the existing building. The extent of the demolition is shown below.

Figure 6.4 Sections of Existing Building to be Removed for New Woodchip Reception



This extent corresponds to a step in the building. It also provides sufficient space for a third silo for a future boiler if needed. The reason for doing this now is to ensure a complete structural solution can be provided. The relatively poor ground conditions mean that piling is required to prevent overturning of the silos. For all three silos the total equipment and contents weigh approximately 400 Tonnes.

The new building would incorporate a concrete roof to provide support for the silos, push/pull floor and screw feeders. It also provides a means of access for maintenance. It would also provide a limited amount of acoustic separation for the occupants below.

The building would have a typical light industrial / commercial fitout. A high level of fitout and finish is not required to match the existing building.

A 2 m high screen would be provided around the silos to hide the push/pull floor and screwfeeder equipment. It also provides a safety barrier from falling.

Figure 6.5 Typical Woodchip Silo
 (from Brightwater Engineering)



Silo (800m³, 10m diameter and 18m high)



En-Masse conveyor

6.6 Woodchip Transport System

Now that all the major equipment has been located, the woodchip transport system can be selected.

There are two systems:

- The feed from the below ground reception hopper to the bulk silos
- The feed from the bulk silo to the boilers.

The basic duties of the transport systems are:

Table 6-1 Overall Duties of the Woodchip Transport Systems

	Feed Screw From Reception Hopper to Conveyor	Conveyor to Bulk Silos	Feed Screws to Each Boiler
Delivery Capacity (minimum)	40 m ³ /hr 13 T/hr		8.4 m ³ /hr 2.8 T/hr
Vertical Lift	0 m	22 m	0 m
Horizontal Distance	12 m	23 m	10 m

There are a number of possible transport systems; pneumatic, en-masse conveyor and bucket elevators.

Pneumatic systems are not proposed as wear is likely to be an issue. Bucket elevators are relatively bulky when the weatherproofing enclosure is included. Therefore en-masse conveyors are proposed.

En-masse conveyors are essentially a chain system with extra wide blades to pull the woodchips along. It is similar to a drag chain system.

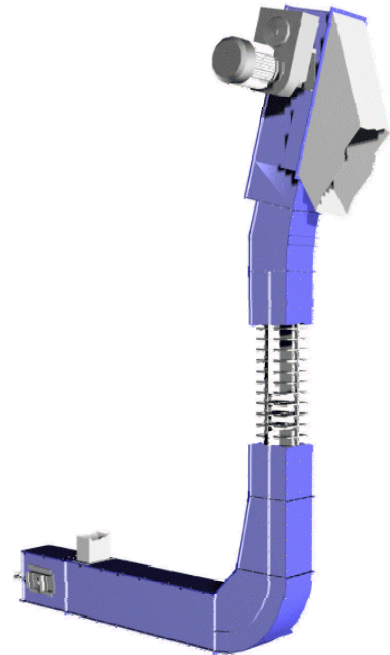


Figure 6.6 Typical En-masse Conveyor
 (from Redler Ltd catalogue)

The table below shows the indicative electrical requirements.

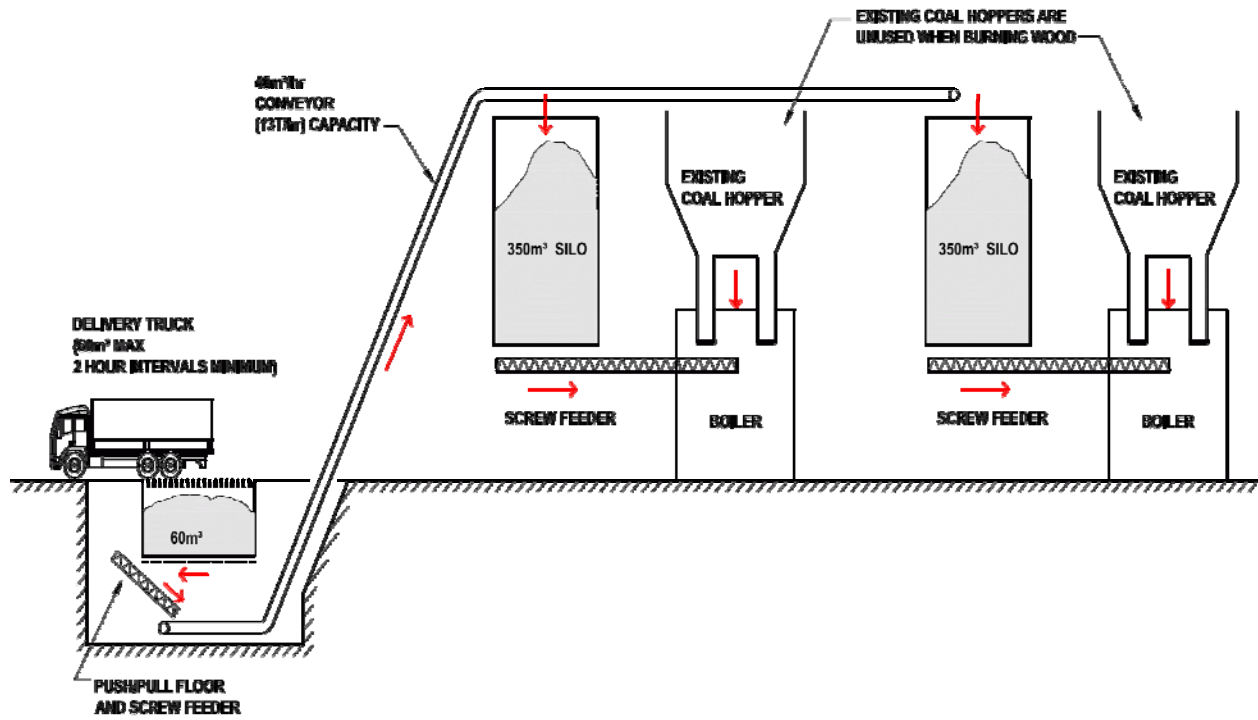
Table 6-2 Indicative Electrical Loads on the Woodchip Transport Systems

	Indicative Motor Size
Reception Push/Pull Floor	11 kW
Reception Feedscrew	4kW
En-Masse Conveyor	15 kW
Bulk Silo Boiler 1 Push/Pull Floor	7.5 kW
Bulk Silo Boiler 1 Push/Pull Floor	7.5 kW
Boiler 1 Feed Screw	3 kW
Boiler 2 Feed Screw	3 kW
Total	51 kW

6.7 Overall System Schematic

Combining the previous sections together gives an overall system schematic as shown below.

Figure 6.7 Process Diagram of Woodchip Handling and Storage System



7 Boiler and Ancillary Systems

This section deals with boiler aspects of the projects and covers three main areas:

- Combustion
- Ash Removal
- Ancillary Systems

7.1 Combustion Aspects

As part of the boiler replacement project, the basic construction of the new coal boilers are being specified as being suitable for burning woodchips. So, in terms of the basic boiler shell and grate construction, there are theoretically no changes required. However on a practical level, an optimised woodchip boiler is different to an optimised coal boiler. The main difference relates to the type of stoker; whether it is a moving grate type or a spreader stoker. The former is more suited to coal and in general, produces a lower level of emissions leaving the combustion chamber. The flue gases then pass through a multicyclone filter then a bag filter. As a result of these downstream emission control devices, a lower emission level from the boiler does not always produce a correspondingly reduction in the chimney emissions.

The proposed boiler configuration is a spreader stoker feeding onto a moving grate. A coal-only boiler would have a gravity feeder onto the grate. So the change to wood firing replaces this with the spreader stoker. This is the key change to the boiler specification as a result of the change to wood firing.

A lesser issue is that more combustion air is needed on wood than coal. The boilers are being specified as being suitable to burn lignite coal. This allows future flexibility. The following table shows the relative amounts of air required for different fuels:

Table 7-1 Nominal Flue Gas Flow Rates for Different Fuels in a 7MW output boiler

	Current Coal Blend	Southland Lignite	Woodchips ("Moist")
Moisture Content	20%	40%	40%
Gross Calorific Value (MJ/kg)	23.5	14.0	12
Air Flow Required (Nm ³ /hr)	25,700	26,800	29,400
Difference (Relative to Lignite option)	-4%	--	+10%
Wet Flue Gas Flow (m ³ /hr)	45,600	51,600	58,700
Difference (Relative to Lignite option)	-12%	--	+14%

Thus the change to woodfired boilers requires larger Forced Draught (FD) and Induced Draught (ID) fans on the boilers.

The final change relates to the control system. The quality and moisture content of woodchips is more variable than coal so extra controls programming and combustion tuning has been included in the capital cost estimates over the current coal design.

7.2 Ash Removal

The propose ash removal system from the coal boilers is a submerged drag chain system. Wood ash has a tendency to float so the system is not suitable without modification. Additional water sprays, recirculating water pumps and a settling tank have been included to wet the ash and help transport it.

7.3 Ancillary Systems – Fire Protection

Under the boiler replacement project scope, fire sprinklers are being installed. These would be extended to cover the wood handling areas and the new building under the wood silos. This is to prevent fire spread to and from the silos above. Note that the silos will have explosion relief vents.

7.4 Ancillary Systems – Ventilation

The underground wood handling systems will require ventilation to ensure a safe atmosphere and to remove dust.

8 Installation Sequence

As the supply of steam to the hospital must continue during all construction work, the installation sequence is critical and does introduce additional cost to the project.

The diesel boiler must be installed early to allow work to be carried out on the flue ductwork. However, the running costs are very high. So the diesel boiler operation must be minimised. Note that diesel boiler alone cannot cope with the entire steam load on cool and cold days.

This means that the coal boilers, and hence the coal system must be kept operational for the bulk of the construction period. As the new wood reception facility is located immediately beside the existing coal handling bucket elevator, for safety reasons, and practicality, the bucket elevator must be stopped while this construction is carried out. Therefore the coal must be craned into the overhead hoppers during this time. This is not difficult as there is a lightweight roof. If done over summer, the hoppers can be filled every couple of days if two coal boilers are kept operational. A high degree of planning is needed to coordinate a series of coal delivery trucks with the crane hire and temporary removal of the roof.

Another major issue is providing a working space for the contractor. The site is very constrained. The proposed approach is to demolish the building on Antigua Street early on. This space would be used by the Contractor while he constructs the wood reception. Once complete, he will move his area close to the reception, to provide space to build the new building and silos.

The current occupants of the demolished building that will be returning to the new building need to temporary accommodation. It is suggested that Portacom type temporary accommodation be provided in driveways further along St Asaph Street.

9 Project Timetable

The following construction programme is proposed. Obviously one of the key issues is getting the change from coal to wood approved (and financed). For the purposes of this report, it has been assumed that this takes 3 months.

The Resource Consent for the boilers currently being sought includes wood firing. So there should be no regulatory holdups.

Table 9-1 Expected Project Programme

Item	Duration	Start Date	Completion
Approval to Proceed		1-Apr-09	1-Apr-09
Design and Tender Document Preparation	14 wks	1-Apr-09	7-Jul-09
Tendering and Approvals	8 wks	8-Jul-09	1-Sep-09
Award of Main Contract		1-Sep-09	1-Sep-09
Resource Consent Granted		30-Jun-09	30-Jun-09
Structural Work			
Structural Modifications - for diesel boilers	8 wks	27-Jan-10	23-Mar-10
Structural Modifications - for wood boilers	14 wks	24-Mar-10	29-Jun-10
Remedial Seismic Work & Bagfilter Supports	26 wks	27-Jan-10	27-Jul-10
Boiler 1 (Diesel Boiler)			
New Boiler 1 Fabrication and Delivery	26 wks	2-Sep-09	2-Mar-10
New Boiler 1 Installation and Testing	16 wks	24-Mar-10	13-Jul-10
Wood Handling System			
Excavate and Construct Wood Reception	18 wks	2-Sep-09	5-Jan-10
Construct Temporary Staff Accommodation	6 wks	2-Sep-09	13-Oct-09
Demolish Existing Building Facing Antigua St	4 wks	14-Oct-09	10-Nov-09
Construct New Building	20 wks	11-Nov-09	30-Mar-10
Install New Silos	6 wks	31-Mar-10	11-May-10
Boiler 2 (1st Wood Boiler)			
New Boiler 2 Fabrication and Delivery	48 wks	2-Sep-09	3-Aug-10
New Boiler 2 Installation and Testing	16 wks	25-Aug-10	14-Dec-10
Boiler 3 (2nd Wood Boiler)			
New Boiler 3 Fabrication and Delivery	48 wks	23-Dec-09	23-Nov-10
New Boiler 3 Installation and Testing	12 wks	15-Dec-10	8-Mar-11
Removal of Third Existing Boiler	3 wks	9-Mar-11	29-Mar-11
Handover To Client		29-Mar-11	29-Mar-11
Fine Tuning and Reliability Testing	8 wks	30-Mar-11	24-May-11

10 Capital Costs and Operating Costs

10.1 Capital Costs

The estimated capital costs are tabulated below. These are in 2008 dollars and exclude GST. Note that inflation allowances need to be included if the project is delayed. In addition, an additional allowance should be made for equipment fabricated and delivered during the latter stages of the project (This includes a portion of the first wood boiler and the entire second wood boiler price.

Table 10-1 Estimated Project Capital Costs

Ref	Item	Capital Cost	Comment
1	New Woodchip Reception		
1.1	Clear the area and excavation	\$52,000	Incl disposal of material
1.2	Reinforced concrete structure	\$193,000	
1.3	Above ground enclosure	\$2,000	
1.4	Security fencing and gates	\$10,000	
1.5	Access stairway & service hatch	\$15,000	
1.6	Structural steel	\$30,000	
1.7	Hopper, moving floor, feedscrews, grizzly	\$333,000	* Includes hydraulic system
2	Demolish Building to the East		
2.1	Demolition	\$20,000	Two story 130m ² footprint
2.2	Temporary blanking off & weatherproofing	\$15,000	
3	Relocated Staff - Temporary		
3.1	"Portacom" type	\$90,000	Approx 130m ² , with services
4	Relocated Staff - Permanent		
4.1	New building (on nearby site)	\$325,000	Approx 130m ² , with services
5	New Building		
5.1	Standard construction	\$325,000	Approx 130m ² , with services
5.2	Additional for structure to support silos above	\$110,000	Incl access stairway,
5.3	Additional to tie into boilerhouse structure	\$40,000	
6	Wood Transport and Storage Silos		
6.1	En-Masse conveyor	\$363,000	* 13 T/hr capacity
6.2	Storage Silo 1	\$880,000	* 350 m ³ capacity
6.3	Storage Silo 2	\$880,000	* 350 m ³ capacity
6.4	Boiler screw feeds	\$22,000	*
6.5	Structural preparation	\$40,000	Incl feedscrews through boilerhouse
7	Boiler Changes		
7.1	Stoker changes and wood feed	\$600,000	
7.2	Larger ID and FD Fans	\$30,000	
7.3	Additional controls programming	\$12,000	For variability in wood fuel
8	Electrical - Power		
8.1	Additional incoming supply & MCC	\$80,000	50 kW additional load
8.2	Variable Speed Drives	\$32,000	
8.3	Wiring Installation	\$25,000	
9	Controls		
9.1	PLC, instrumentation & programming	\$90,000	
9.2	Additional integration with Hospital BMS	\$8,000	Additional status screens
10	Coal Handling - Scope Reduction		
10.1	No overhaul required	-\$25,000	No need to overhaul the system

Ref	Item	Capital Cost	Comment
10.2	Temporary craning in of coal	\$15,000	Roof removal, tarpaulin
11	Building Services - Fire Protection		
11.1	Additional sprinklers and hydrants	\$25,000	For silos
12	Building Services - Ventilation		
12.1	Ventilation for underground area	\$18,000	Inlet fan and passive exhaust
13	Building Services - Plumbing & Drainage		
13.1	Sump pump and drainage	\$8,000	
14	Contractors Preliminary & General (3%) #	\$140,000	
15	Engineering and Project Management	\$250,000	
16	Fees and Consents	\$10,000	Building Consents Prep & Processing
17	General Contingency (10%)	\$506,000	
Total		\$ 5,569,000	

* Wood handling system cost estimates are based on information provided by Brightwater Engineering who are specialists in this type of equipment.

This is the incremental P&G requirements in addition to that already allowed in the coal boiler replacement cost estimates.

10.2 Operating Costs

There are two components to the operating costs: the fuel costs and the additional costs due to the use of wood as a fuel rather than coal. Note that all the non-fuel costs are incremental costs over the coal. For example, diesel costs in the backup boiler have not been included as they are assumed to be constant and not affected by the coal / wood fuel choice.

The annual wood use over the next 20 years is tabulated on the next page. Two different moisture contents have been assumed to show the effect it has.

Table 10-2 Estimated Additional Non-Fuel Operating Costs (Above Coal Costs)

Item	Annual Cost	Comments
CDHB Staff Costs for Monitoring Wood Energy Content	7,000	1 hours/week for a staff member + annual costs for accountant
CDHB Staff Costs for Responding to Fuel Blockages	12,000	3 hour/fortnight for two staff members
General Maintenance on Woodchip Handling System	20,000	Estimate above existing coal system costs
Total	\$ 39,000	

Table 10-3 Estimated Annual Woodchip Consumption

Year	Delivered Energy Provided by the Solid Fuel Boilers (MWh/yr)	Woodchip Use - Dried (10% Moisture) (Tonne)	Woodchip Use - Undried (15% Moisture in Summer & 24% in Winter) (Tonne)
Year 0	36,400	10,200	11,500
Year 1	36,400	10,200	11,500
Year 2	36,700	10,300	11,600
Year 3	36,900	10,300	11,600
Year 4	37,200	10,400	11,700
Year 5	37,300	10,400	11,700
Year 6	37,600	10,500	11,800
Year 7	39,200	11,000	12,300
Year 8	42,500	11,900	13,400
Year 9	42,500	11,900	13,400
Year 10	42,800	12,000	13,500
Year 11	43,200	12,100	13,600
Year 12	43,500	12,200	13,700
Year 13	43,700	12,200	13,800
Year 14	44,000	12,300	13,800
Year 15	44,400	12,400	14,000
Year 16	44,700	12,500	14,100
Year 17	45,000	12,600	14,200
Year 18	45,400	12,700	14,300
Year 19	45,700	12,800	14,400
Year 20	46,100	12,900	14,500

11 Summary

11.1 Overall Summary

This section provides a list of the key points made in the main body of the report.

- Wood firing of the boilers at Christchurch Hospital is possible and practical.
- Matching the existing level of on-site security of steam supply is possible and practical.
- Matching the security of off-site supply is more difficult as it involves external organisations. However, a number of contractual requirements can be included in a woodchip supply contract to minimise the effect of equipment failures or financial problems.
- Ultimately a conversion to coal is always possible.
- The cramped site means that there are very few options, if any, on plant layout. Thus the detail present in this report is necessary to demonstrate a workable solution.
- A financial review of the economics is covered under a separate section of this report.

11.2 Wood Supply Conditions

- The current market price for wood pellets makes them uneconomic. In addition, it is expected that the relatively young market and limited number of suppliers would concern the CDHB.
- Payment should be based on the energy content in the fuel with a small reduction in price for increasing moisture content (to reflect the increasing handling and combustion costs associated with an increasing mass of fuel).
- Off site woodchip storage must be covered.
- The woodchip supplier must have at least two wood chipping plants and at least two delivery trucks.
- The woodchip supplier would also remove the ash and dispose of it. This is what currently happens with the coal supply contract.

11.3 Wood Handling and Storage Systems

- The woodchip reception facility must be capable of receiving truck and trailer units to minimise the transport costs (and diesel consumption). This corresponds to a nominal delivery volume of 60 m³.
- The extremely cramped site means that there is only one location for the wood reception.
- More work is needed to fine tune this location as current the truck protrudes onto Antigua Street when emptying the rear trailer.
- The existing coal hoppers are unsuitable for woodchip storage due to their shape and have insufficient volume to maintain the current level of fuel storage. Therefore new storage silos are required.
- Each boiler needs to have a 350 m³ storage silo (approximately match the existing coal storage).
- These silos need to be located adjacent to Antigua Street. There is no other location on site that has sufficient space, can be constructed and provides future flexibility.
- This silo location requires the demolition and rebuilding of a 260 m² portion of the two level building currently occupying this location. The building would be rebuilt as a single level building with the silos on the roof.

- This 130 m² loss of building space would have to be provided elsewhere on site. A basic cost to provide a new building has been included in the capital cost estimates.
- The occupants of the rebuilt portion of the building will require relocation to a temporary building on site. Costs have been included for this.

11.4 Boilers and Ancillary Systems

- The basic boiler construction suitable for wood firing has already been allowed for in the boiler replacement project. However, there are some changes to the stokers, combustion fans and control to make them suitable for wood from the start.
- Additional fire protection and ventilation systems are required for the new construction areas.

11.5 Timetable and Construction Issues

- A decision to change the boilerhouse to wood firing will delay the boiler replacement project. However, agreement from ECan should be sought to delay the requirement for reduced emission levels. A benefit to the environment as a whole is the sustainable aspects of wood firing.
- The construction of a new woodchip reception facility will disable the current coal handling system for a period of nominally 4 months. During this time, coal needs to be craned into the overhead hoppers.
- The staff and facilities currently in the building facing Antigua Street will need to be temporarily accommodated in "Portacom" type cabins elsewhere on site for a period of at least 9 months.

11.6 Capital Costs and Operating Costs

- The estimated capital cost is \$5.6M excluding GST and is in 2008 dollars. An inflation allowance needs to be added as some of the work will occur in 2009 and 2010. This cost includes all engineering fees and a 10% contingency. No internal CDHB costs have been included.
- The cost to re-accommodate the current occupants of the building adjoining the boilerhouse (facing Antigua Street) is approximately \$870,000. This includes permanent new accommodation elsewhere on site for some of the occupants and functions, temporary accommodation for those returning to the new building. The cost includes the relevant portions of the contractors preliminary & general costs, engineering costs and contingency.
- The estimated woodchip consumption will be approximately 10-11,000 T/yr rising to 12-13,000T/yr in the future based on the expected hospital growth. Note this is based on typical annual weather patterns. The cost of this fuel and a market study is the subject of a separate investigation. Hence it is reported separately.
- The estimated annual additional operating costs for using woodchips instead of coal is \$39,000. This covers maintenance on additional plant and equipment and additional staff monitoring.

11.7 Decisions Needed from the CDHB

- The CDHB need to evaluate this technical solution and confirm that it provides an acceptable level of security for the hospital steam supply.
- If so, and an acceptable supply of wood can be obtained at an economic cost, then financial approval should be sought.
- Once gained, an early start on the detailed engineering layout to finalise vehicle paths and Council requirements. This is needed to obtain a firm tender price the project.