4 DISTRICT HEAT SYSTEM

4.1 General Description

A typical district heat system involves the distribution of heat, produced in a centralised plant, to buildings in order to serve heating requirements such as space and domestic hot water heating. The plant is usually a combined heat and electricity plant. In this study a centralised wood-chip boiler plant with a buffer tank and dual wood-chip boilers will provide Medium Temperature Heating Water (MTHW) (maximum 115 °C) via a pre-insulated district heat pipework to substations located in the plant rooms of the buildings. A higher flow water temperature is required to keep the pipework sizes smaller and thus investment costs lower. Some further details regarding equipment required for the district heat system, excluding heating plant, are described in the following paragraphs.

4.2 Plant

For this study it is assumed the centralised heating plant is located on land near the Events Centre, with the optimum location being as close as possible to the Alpine Aqualand plant room. The close proximity to the airport runway would need to be taken into consideration before a location could be finalised and a Resource Consent and Building Consent would be required for the Boiler House. Consideration needs to be given to the potential noise and dust problems associated with fuel delivery.

The plant in this study would consist of two 500 kW wood-chip boilers, one 15,000 litre buffer tank including pipework and pump sets. Underground wood-chip fuel storage is proposed to enable a wood-chip delivery truck to tip wood-chips into the fuel bunker. Because the total annual wood-chip usage is relatively low (2,200 MWh/year ≈ 2,600 m³/year), a sweeping arm fuel bunker system is adequate. If wood fuel usage were to double, a moving floor fuel bunker system would be more suitable.

4.3 Pipework and Trench

Pipework would be reticulated underground from the Boiler House through to the various sites and substations where heating energy is required. The final route for the pipework would only be confirmed following discussions, agreements and after obtaining easements from the various land owners and the associated Building Consents.

The district heat pipework is based on a design pressure of 16 bar and a design temperature of up to 120°C. The pipework is pre-insulated in the factory. More information can be found from the following New Zealand manufacturer's webpage

- Insapipe Industries Ltd, http://www.insapipe.com/

The typical trench construction for the district heat pipework is shown in Figure 4.

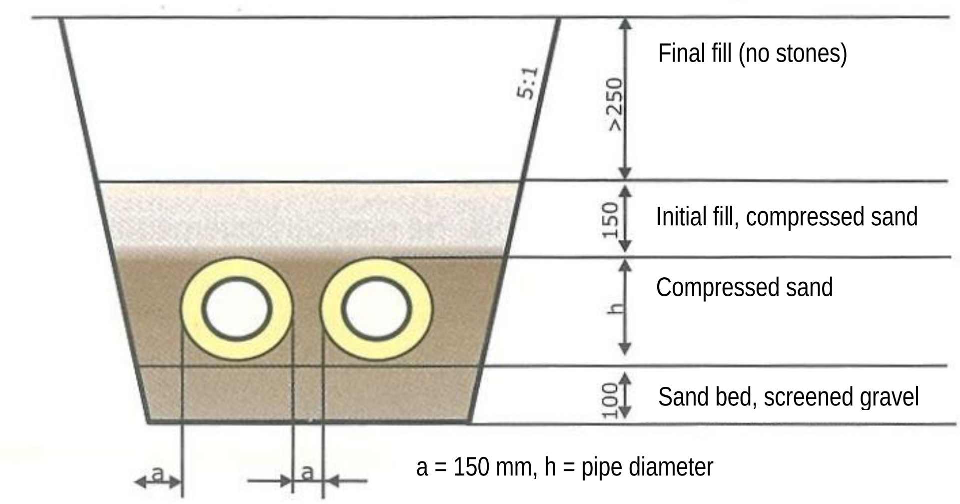

Figure 4 Typical district heat trench detail [2]

4.4 Substation

A substation would be required at each site where the heating energy is to be supplied. Each substation could be a small stand alone building or, more likely, they would be housed within existing plant room areas on each of the sites.

The main components included in a typical district heating substation (Figure 5) are:

- DHW and MTHW heat exchangers (only a MTHW heat exchanger is required in this study)
- Control valves
- Temperature sensors
- Controller
- Circulating pumps
- Expansion vessel and safety valves (secondary side provided by Mechanical Services Contractor)

The substation specifications for the buildings in this study are shown in Appendix 2.

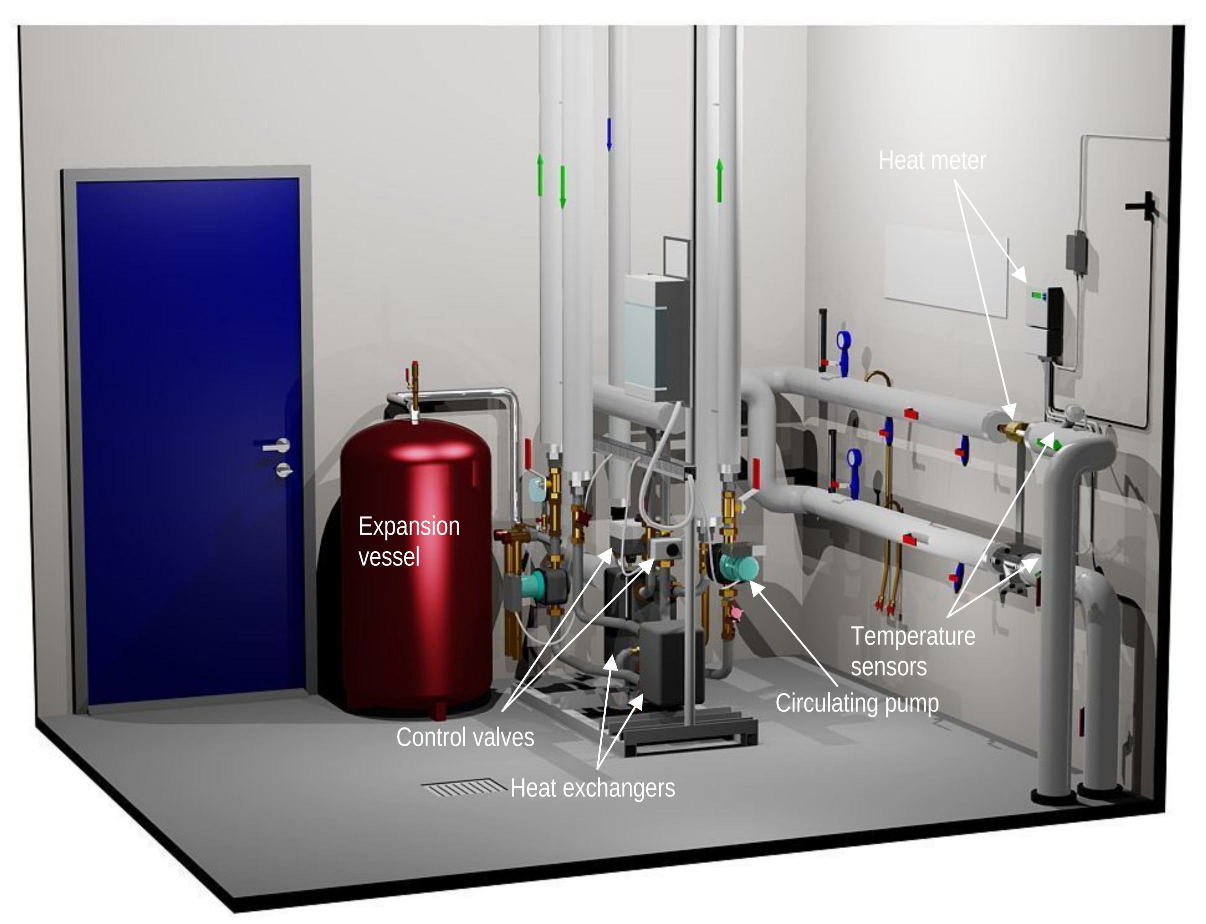

Figure 5 Typical district heating substation [From Fortum Power and Heat Ltd, Finland]

4.5 Heat meter

Each substation would include a heat meter to measure the heating energy supplied to the site via the substation. The heat meter includes a heat flow calculator, flow sensor, temperature sensors and remote reading gear. The most common type available in New Zealand is based on ultrasonic flow sensors.

5 COSTS

5.1 Energy Source Prices

The cost of the fuel for the energy provided by the central boiler plant is indicated in Table 4 and is compared with energy costs of other fuel/energy sources currently used on the sites. The water content of W35 wood-chips is assumed to be 30%.

Table 4 Energy source prices excluding GST

Description	Unit	Wood chip W35	Electricity	Diesel	LPG
Price per volume	[$/m³]	30	N/A	1087	987
Price per mass	[$/tonne]	139	N/A	1286	1838
Price per litre	[$/L]	N/A	N/A	1.087	N/A
Price per energy unit	[$/GJ]	11.0	40.0	30.1	39.9
Price per energy unit	[¢/kWh]	4.0	14.4	10.8	14.4
Price	**[$/MWh]**	**40**	**144**	**108**	**144**

The wood-chips are considered to be carbon neutral and therefore should not be subjected to carbon taxes now or in the in future, where as electricity, LPG and diesel are subject to carbon taxes. Potential carbon taxes have been ignored in this report.

5.2 Investment Costs

The investment costs for the centralised boiler system are divided into the costs for the building work, plant and equipment costs (Table 5). The plant consists of the two wood-chip boilers, (500 kW nominal output each), buffer tank (15,000 L capacity) and dual circulating pumps.

The plant costs and heating reticulation systems connection costs (including heat meter) are estimated based on other similar projects. The excavation work pricing is based on rates supplied by Groundworks Ltd, based in Queenstown. The district heating pipework prices were provided by Insapipe Ltd and the substation prices were provided by Alfa Laval.

The costs of the new heating pipework system and modifications for radiant heaters in the Events Centre are not included in the investment costs as these would be paid by the owner of the building. However, the total cost is estimated to be around $80,000.

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Table 5 Investment costs for the central heating system (excluding GST)

Building work	Unit	Cost exc. GST
Boiler room, fuel bunker, roading, etc.	[$]	300,000
Excavation work for district heating pipework (1570m x $120/m)	[$]	188,400
Total building work costs	**[$]**	**488,400**
Plant and equipment		Cost exc. GST
Plant (dual wood-chip boiler and buffer tank)	[$]	1,300,000
District heating pipework DN80 (1300m x $338/m)	[$]	439,400
District heating pipework DN50 (270m x $233/m)	[$]	62,910
Substations - Aquatic Centre	[$]	11,739
Connection costs including heat meter - Aquatic Centre	[$]	17,608
Substations - Queenstown Airport	[$]	9,373
Connection costs including heat meter - Queenstown Airport	[$]	14,059
Substations - Lakes District Hospital	[$]	6,533
Connection costs including heat meter - Lakes District Hospital	[$]	9,800
Substations - Events Centre	[$]	5,647
Connection costs including heat meter - Events Centre	[$]	8,470
Total plant and equipment costs	**[$]**	**1,885,538**
Total investment cost	**[$]**	**2,373,938**

5.3 Annual Costs

For this case study, an interest rate of 8% is used. The operating life is 20 years for the plant and equipment and 30 years for the building. The capital recovery factor is used to calculate the annual capital costs from the investment costs. This is the same principle as for bank loans when the same amount is paid back each year. The annual repair costs of the plant are based on the Bioheat Final Report [3]. It is assumed that in New Zealand conditions the plant and equipment annual repair costs are 1% of the total plant and equipment investment costs. The building annual repair costs are given as 0.5% of the total building work investment costs. The operating life, capital recovery factor and annual repair costs as a percentage of investment costs are shown in Table 6.

Table 6 Operating life, capital recovery factor and annual repair costs as a percentage of investment costs for the plant and equipment, and building

Description	**Unit**	**Plant and equipment**	**Building**
Operating life	[years]	20	30
Capital recovery factor [1]	[%]	10.2	8.9
Annual repair costs [1]	[%]	1.0	0.5

[1] From reference [3]

The annual costs are divided into capital, demand related and operation related costs. The investment costs presented in Table 5 are converted into capital costs in Table 7 using the capital recovery factors from Table 6. For the demand related costs, the electricity costs include the pumps, fans and electricity usage of the plant. The repair costs for the plant, installation and building in Table 7 are calculated using the annual repair cost percentages of the investment costs from Table 6. It is assumed the wood-chip boiler maintenance takes a total of 64 hours each year at $60/hr. The costs per energy unit do not include profit margin for the district heating company.

Table 7 Annual costs for the central heating system (excluding GST)

Capital costs (interest + depreciation)	Unit	Cost exc. GST
Building work	[$/year]	43,383
Plant and equipment	[$/year]	192,046
Total capital costs	**[$/year]**	**235,430**
COSTS PER ENERGY UNIT	**[$/MWh]**	**126**
Demand related costs		
Annual wood chip costs today (80% efficiency)	[$/year]	92,504
Electricity costs (pumps, fans, etc.)	[$/year]	3,000
Total demand releted costs	**[$/year]**	**95,504**
COSTS PER ENERGY UNIT	**[$/MWh]**	**51**
Operation related costs		
Repair cost of building	[$/year]	2,442
Repair cost of material and installation	[$/year]	18,855
Maintanence cost	[$/year]	3,840
Total operation related costs	**[$/year]**	**25,137**
COSTS PER ENERGY UNIT	**[$/MWh]**	**13**
Total annual costs	**[$/a]**	**356,071**
TOTAL COSTS PER ENERGY UNIT	**[$/MWh]**	**191**
TOTAL COSTS PER ENERGY UNIT	**[¢/kWh]**	**19.1**

Annual costs excluding GST for the existing heating systems in this study are shown in Table 8. The annual performance efficiency of 176% for the existing water-to-water heat pump system at hospital considers electricity usage of the lake pumps (53 MWh electricity per annum) and electrically boost heated DHW (13.8 MWh electricity per annum). The maintenance costs of plant and equipment for the hospital come from a report prepared by Spotless Services Ltd.

The investment, repairs and maintenance costs for heat generating plants in other buildings is included for the gas and diesel boilers and is based on an annual service and a plant life of approximately 15 years.

The investment, maintenance and repair costs for electrically heated buildings are considered to be nil as there is no main heating plant.

Table 8 Annual costs for the existing heating systems in this study

Values	Unit	Existing diesel boiler system at Airport	Existing water-to-water heat pump system at Hospital	Existing LPG boiler system at Alpine Aqualand	Existing electric heating system at Events Centre	TOTAL
Heating energy usage	[MWh/year]	446	605	518	300	1,869
Annual efficiency	[%]	85	176	90	100	107
Fuel usage	[MWh]	525	344	576	300	1,744
Delivered fuel cost	[$/MWh]	108	144	144	144	N/A
Demand related costs						
Annual fuel cost	[$/year]	56,892	49,489	82,592	43,200	232,172
Electricity costs (pumps, fans, etc.)	[$/year]	500	500	500	0	1,500
Total demand releted costs	**[$/year]**	**57,392**	**49,989**	**83,092**	**43,200**	**233,672**
Operation related costs						
Repair and replacement cost of plant	[$/year]	1,500	20,267	1,500	0	23,267
Maintanence cost	[$/year]	500	12,800	500	0	13,800
Total operation related costs	**[$/year]**	**2,000**	**33,067**	**2,000**	**0**	**37,067**
Total annual costs	**[$/a]**	**59,392**	**83,055**	**85,092**	**43,200**	**270,739**
COSTS PER ENERGY UNIT	**[$/MWh]**	**133**	**137**	**164**	**144**	**145**
COSTS PER ENERGY UNIT	**[¢/kWh]**	**13.3**	**13.7**	**16.4**	**14.4**	**14.5**

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6 CONCLUSIONS

This report has been commissioned by Queenstown Lakes District Council to ascertain the viability of using a wood-chip boiler type area heating system to provide hot water heating for Queenstown Airport, Lakes District Hospital, Alpine Aqualand (swimming pool) and the Queenstown Events Centre.

The peak heat load demand with overlapping diversity was estimated to be 1,000 kW and the heating energy usage 1,869 MWh annually.

The centralised wood-chip boiler plant described in this study is not considered to be feasible as the actual energy supply costs (including maintenance and investment costs), are higher than the existing energy supply costs for the various sites. The study did not include any profit margins on the energy supply costs which when added would further decrease the feasibility.

The main points that affect the viability of this proposed district heating scheme are as follows:

- *The bulk of the existing heating is provided via heat pump systems.* The existing heat pump systems in the Queenstown Airport and Alpine Aqualand are providing the bulk of the heating energy to these sites with the high efficiencies that can be achieved with heat pump systems. For the airport, there is the added benefit that these heat pumps also provide mechanical cooling. With the current electricity prices, the centralised heating system cannot compete due to the high capital investment cost.
- *Low heating energy demand compared to peak heat load.* The sites in this study have a high peak LTHW energy use but a low overall LTHW energy demand. This is due to the existing LPG and diesel boilers at the Alpine Aqualand and Queenstown Airport primarily being there to assist with peak winter heating loads when the heat pump system performance drops off due to low outside air temperatures. This results in low total LTHW energy usage.

The following factors should be considered when investigating the viability of potential wood energy district heating schemes:

- Preference for high energy users in close proximity to one another.
- Suitable site available for the Boiler House with consideration given to the potential issues with noise and dust associated with the fuel delivery.

- Potential energy users with a preference to using LTHW heating (such as hotels and rest homes with high DHW loads and LTHW space heating with little cooling required).
- Potential energy users that require heat energy at a temperature above 65ºC (such as for DHW heating or process heating).
- Potential energy users that do not need a lot of mechanical cooling (e.g. retail stores, restaurants and bars are not really suitable).
- Sites where heat pump systems would also be an option are unlikely to be suitable as the heat pump energy costs are likely to be similar or lower than LTHW heat supplied by a wood energy district heating scheme (e.g. swimming pools or sites where underfloor heating primarily used).
- Households are also unlikely to be suitable as the supplied energy cost could not compete with other energy options such as wood burners, small wood fuelled boilers, split system heat pumps, air to water and ground source heat pumps for underfloor heating systems.

7 REFERENCES

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APPENDIX 1 OVERALL SITE PLAN OF LAKES DISTRICT HOSPITAL

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APPENDIX 2 SUBSTATION SPECIFICATIONS FOR THE BUILDINGS

HEAT EXCHANGER	Unit	HX1 - Alpine Aqualand		HX2 - Airport		HX3 - Hospital		HX4 - Events Centre	
Make		Alfa Laval		Alfa Laval		Alfa Laval		Alfa Laval	
Model		Maxi 500 Siemens		Maxi 400 Siemens		Maxi 130 Siemens		Maxi 150 Siemens	
Type		CB77-150M 4C-HES		CB77-100M 4C-HES		CB76-40M 6C-HES		CB52-50L 6C-HES	
Output	kW	500		400		130		150	
		Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Flow rate	dm³/s	2.90	12.2	2.34	9.8	0.48	3.1	0.72	1.8
Temperatures	ºC-ºC	115 - 71.7	70 - 80	115 - 72	70 - 80	115 - 46.5	45 - 55	115-62.5	60-80
Pressure drop (maximum)	kPa	2	19	2	20	0	12	3	19
Design pressure	MPa	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6
Material		AISI 316		AISI 316		AISI 316		AISI 316	
CONTROLLER		TC1 - Alpine Aqualand		TC2 - Airport		TC3 - Hospital		TC4 - Events Centre	
Make		Siemens		Siemens		Siemens		Siemens	
Model		RVD 144		RVD 144		RVD 144		RVD 144	
CONTROL VALVE		MV1 - Alpine Aqualand		MV2 - Airport		MV3 - Hospital		MV4 - Events Centre	
Make		Siemens		Siemens		Siemens		Siemens	
Model		VVF52		VVF52		VVG549		VVG549	
Flow rate	dm³/s	2.9		2.34		0.48		0.72	
Pressure drop	kPa	70		45		47		42	
Size/kvs-value	DN/kvs	40/12.5		40/12.5		15/2.5		20/4.0	
Actuator		SKD 32.50		SKD 32.50		SSY 319		SSY 319	
Control signal/Voltage	V	230V / 3-step		230V / 3-step		230V / 3-step		230V / 3-step	
CIRCULATING PUMP		P1 - Alpine Aqualand		P2 - Airport		P3 - Hospital		P4 - Events Centre	
Make		Existing		Existing		Existing		Not included	
Model		-		-		-		-	
Flow rate	dm³/s	12.2		9.8		3.1		1.8	
Head	kPa	-		-		-		60	
Nominal current / Voltage	A / V	-		-		-		-	
EXPANSION VESSEL		EV1 - Alpine Aqualand		EV2 - Airport		EV3 - Hospital		EV4 - Events Centre	
Network volume / pressure drop	dm³/kPa	-		-		-		2100/40	
Expansion vessel volume / Precharge pressure	dm³/kPa	Existing		Existing		Existing		250/150 (not inc.)	
SAFETY VALVE		SV1 - Alpine Aqualand		SV2 - Airport		SV3 - Hospital		SV4 - Events Centre	
Size of safety valve / relief pressure	DN/kPa	Existing		Existing		Existing		20/250 (not inc.)	