T4 Sustainability Ltd

Bakewell Town & Community Trust

Peak District Spring Water Source Heat Pump Opportunities

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Copyright and Acknowledgements

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Contents

1 - Aims and Objectives

This document has been commissioned specifically to examine the opportunities to exploit warm spring water as an energy source for space and water heating.

It is not intended to cover the detailed design of such systems which will vary as the choice of available heat pumps matures, but as an example of the feasibility study process, it will consider the space heating requirements of the Bakewell Town Hall building located at

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The Square,
Bakewell,
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and determine the spring water resources required to meet these.

While this is apparently a straightforward engineering task, the range of uses to which the building might be put must be kept in mind, as must alternative sources of heat which may provide at least a part of the required thermal energy.

Other renewable energy options appropriate to a community building in the Peak District National Park are considered, and the feasibility of warm spring water source heat pumps evaluated using an approach that quantifies the likely energy outputs, carbon emissions, and environmental performance.

The Trust has also raised the issue of the provision of air conditioning in some parts of the building, though no detailed requirement has been identified. This should be kept in mind when reviewing the options for managing energy in the building, along with opportunities to insulate the building and exploit less energy intensive means of ventilation and 'comfort cooling'.

2 - Introduction

There are a number of sites in the Peak District where warm springs rise to the surface. The temperature of these varies very little with the season, and for all practical purposes the spring outlet temperature at a given site can be regarded as constant.

These springs then offer a source of heat energy, albeit low grade heat, and have aroused considerable curiosity over the years, as to their potential as an energy source.

Low temperatures have generally precluded the use of these springs as a direct heat source, but the increasing availability and deployment of heat pumps in the UK is now making the use of this heat a possibility with technology which while expensive, is 'off the shelf', and well tried and tested in other parts of the world.

Perhaps because the UK has had access to cheap natural gas from the North Sea, where as European countries have mostly had relatively high energy prices, the uptake of heat pumps in the UK has been relatively poor until recent times, and we are now only slowly catching up with our European and Scandinavian neighbours. This may have been reinforced by the relatively wide spread availability of three phase domestic electrical supplies in Europe.

At a time when the need for sustainable consumption of locally sourced energy has never been more clear, options to use renewable energy in the Peak District National Park are constrained by the need to conserve the visual environment. This precludes many opportunities to exploit wind power and solar resources, but heat pumps have the advantage that in many circumstances, little or no infrastructure need be visible or prominent in the landscape, yet significant amounts of thermal energy can be obtained with significantly lower carbon emissions than would arise from the burning of natural gas which is widely seen as the current benchmark for efficient space heating.

Although this work concentrates primarily on a site in Bakewell, the feasibility study methodology should apply equally to other locations in the Peak district, including Matlock and Buxton, and to sites in any location where there is a demand for heat, and water is available at a constant temperature.

Information provided by Jan Stetka via the Bakewell Town and Community Trust indicates the following spring water temperatures.

Bakewell	15°C
Matlock	20°C
Buxton	25°C

Note however, that an article from the Peak Advertiser dated the 24th of November 1997 entitled "The Secrets Of Bakewell Bath House" (© Julie Bunting 1997), refers to a temperature of only 11.6°C in Bakewell, but by contrast, 27.5°C in Buxton.

Although the focus of this work is on heat pump requirements and performance, heating system designers should attempt to design systems with well integrated components and controls, that accommodate all of the requirements of a building and its users.

If air conditioning is required for the Bakewell Town Hall building, this should be taken into account at the detailed design stage as it may have an impact on the type of heat pump technology that it is appropriate to use in the building.

3 - Bakewell Town Hall - The Current Situation

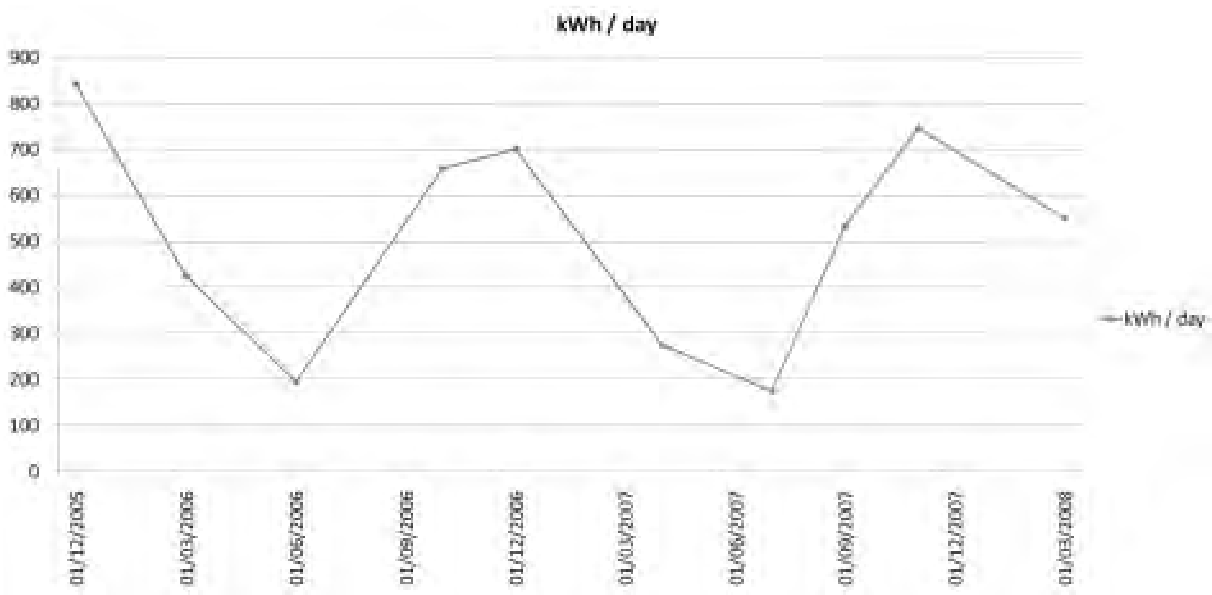
The building is currently heated by an old non condensing gas boiler, the burner of which appears to be rated to modulate between 72.5 and 174 kW.

While this indicates the possible range of heat outputs and the peak rate of energy transfer to the building, it gives no indication of typical daily duration or duty cycle of operation, or actual energy used.

Some information about energy use can be gained from the gas utility bills provided for the building, though the quality of this information is limited by its duration and some gaps in the data, and most billing periods start or end with at least one estimated reading.

Although the data gives a graph with a pleasingly plausible shape, it is not clear if this is truly representative of energy use, or the quality of the estimation technique employed.

It must be kept in mind that each point on the graph represents an average number of kWh per day of gas energy input to the boiler during a billing period. The peak gas energy input on the coldest days may have been much higher than the peaks



shown on the graph, but the energy delivered to the building would be substantially less because, given its age, the boiler efficiency is likely to be poor, perhaps between 60 and 75%. Boiler maintenance records may include flue gas analysis data that might indicate a more precise figure. If they do not, flue gas analysis could be undertaken to assess the efficiency

Allowing for the above, the graph above invites the conclusion that peak daily gas energy input may on occasions exceed 1,000 kWh per day, and aggregating data from energy invoices indicates that total gas energy input may exceed 160,000 kWh per year.

4 - Option Analysis

While this document will focus on the use of spring water as an energy source, it is important for the developers of projects to evaluate all options while taking account of local norms and relevant planning guidance. Within the Peak District, "Supplementary Planning Guidance For Energy Renewables and Conservation" is a document of particular significance.

This evaluation should take account of likely changes to conventional fuel prices, the desirability of reducing dependency on fossil fuels, fuel security, and making long term cuts in carbon emissions.

Adding insulation to buildings may offer the most cost effective gains. In addition to reducing ongoing fuel costs, it will reduce the size of the heating system required, which in turn reduces the capital spend required when premises are refurbished.

In the case of Bakewell Town Hall, the addition of insulation to the walls and floor of the building would be a significant task and is regarded as impractical because of the loss of space that would be incurred in a number of rooms. It may however be possible to add insulation to some parts of the roof. Though worthwhile, this is only likely to reduce the space heating requirement by a modest percentage, as might better management of ventilation and automatic door closing, or the use of vestibules to prevent the mass flow of air as users enter the building.

The use of a range of renewable energy options has been discussed, but most were rejected for the reasons summarised below.

Solar water heating was thought unlikely to be a significant benefit as the demand for hot water in the building is relatively low, and the length of the pipe runs to existing points of use would be significant. Planning issues might also need to be overcome because of the visual impact of solar panels on a building at such a location.

Hydro power was rejected as there is no direct access to the river from the site.

Biomass was not recommended as there was no obvious place to store fuel.

A wind turbine is unlikely to yield significant amounts of energy in the turbulent air of an urban setting, and was also felt to be inappropriate mounted on, or within, the curtilage of a historic building.

The inclusion of a heat pump in the scheme was considered as it would cut green house gas emissions by displacing fossil fuels that would otherwise be used to heat the building, and reduce operating costs at a time when gas prices were rising faster than electricity. It was noted however, that to be efficient, (to get the best coefficient of performance), under floor heating would need to be installed in the building, and this was rejected on the grounds of cost and the disruption likely to be caused.

While it is tempting to assume that the lowest revenue heating costs will be incurred by the use of water source heat pumps, if the building is to be cooled by air conditioning in summer, it is important to consider if bidirectional heat pumps should also be used for cooling.

As reversing the direction in which gas is pumped by a heat pump compressor reverses the direction of heat flow, in principle it is a simple matter to use any heat pump for cooling. Unfortunately many heat pumps are constructed in ways which preclude reversible operation, and where heat pumps are built to be reversible, they may not be as efficient as their non-reversible counterparts.

Note also that heat pump efficiencies in cooling applications are lower (coefficients of performance 1 less in cooling than heating mode).

If at all possible, to save energy, the use of heat pumps for cooling should be avoided in favour of natural ventilation (open windows or passive stack), or forced (fan assisted) ventilation.

Given the lack of clarity about the cooling requirement if any, this paper will now focus on heating, but this issue must be resolved before detailed design can be undertaken.

5 - Introduction to Heat Pumps

A heat pump is a device that transfers thermal energy from one location and medium to another, though more importantly for our present purpose, it has the property that the heat energy delivered by the system can be at a higher temperature to the heat source.

As heat is moved from one place to another, the *heat source* is cooled, and the destination, usually referred to in the terminology of thermodynamics, as the *heat sink*, is warmed.

Common examples of heat pumps include refrigeration systems where the heat source is the inside of an insulated box (the interior of a fridge), and the heat sink is the 'radiator' at the back of the fridge which feels warm to the touch.

When used to heat buildings, heat is moved the other way, from some medium outside the building, normally the ground, the air, or water, to the inside of the building, the 'insulated box'. Here, it is typically distributed by radiators or an under floor heating system. In the process, the ground, air or water outside is cooled, and the temperature of the building is increased.

In addition to thermal energy from the heat source, energy is required for a heat pump to operate. The greater the temperature difference between the heat source and sink, the more energy is required to move a given amount of thermal energy from the heat source to the heat sink. Although practical heat pumps almost invariably use mechanically driven components, they are generally operated from an external electrical energy source rather than being driven via a mechanical shaft. The use of electrical rather than mechanical drive makes it easier to seal the refrigerant gasses in the system. It is important that these do not leak out, as loss of these materials will cause failure of the system, but more importantly, the chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) chemicals used, either caused damage to stratospheric ozone, are remarkably potent greenhouse gasses, or both. As a consequence of this, heat pumps must be maintained and disposed of with care by competent personnel.

In heating applications, the heat delivered can be assumed to be the sum of the energy obtained from the heat source outside the building to be heated, and the electrical energy provided to operate the heat pump. The performance of such systems is usually indicated by the ratio of heat output power divided by the electrical input power. This is usually termed the coefficient of performance, abbreviated to COP. By current standards, well designed systems with COP values of over 5 are likely to be seen as good performers, where as those with COPs of under four should be examined with care to see if the design can be enhanced, or if they are financially and environmentally beneficial at all. COP values improve as the difference between the heat source and sink temperatures is reduced.

Maintaining an adequate temperature in a building heated by a heat pump requires that at a comfortable internal temperature, the heat loss from the building on the coldest days can be met by the heat available from the heating system. Where a heat pump is used, this requires that either the heat source medium can be continually replaced as it is cooled, e.g. an air source system in which large fans blow high volumes of air through the machine to act as a heat source, or a ground source system in which the soil and rock around pipes buried under ground have a high thermal capacity so that they cool very little as heat for the building is withdrawn.

Air source heat pump systems have the problem that on the coldest days of winter when most heating is required, the outside air temperature is low so the COP is poor. Ice should not be permitted to build up around heat exchange surfaces in air source systems, and the need to defrost these when the air is cold may also reduce efficiency.

Ground source systems have to be large enough that the available thermal capacity of moisture, soil and rock can meet short term peaks in heat demand without excessive cooling, but also large enough that adequate amounts of heat can flow into the ground source system over the course of a year to avoid excessive ongoing local cooling. The success of a ground source system then, depends on the thermal capacity and conductivity of the surrounding soil and rock, but is also influenced by the mass flow of water through the heat source site as water brings relative warmth into the cooled heat source region. The formation of ice should also be avoided around the pipework of ground source systems as less heat will reach the ground source pipe work if ice prevents the flow of water through the soil near the pipes. As a precaution, the pipework of ground source heat pumps is generally filled not with pure water, but with water containing about 33% of a glycol antifreeze. Ethylene glycol (similar to the antifreeze used in many cars) has been used in this application, but we would rather see the use of propylene glycol, as in the event of leaks, accidental contamination, or human contact, this is much less toxic.

In winter then, air source systems typically have to operate with low COPs in frosty conditions, and while well sized ground source systems should operate with source inlet temperatures above freezing, operating temperatures may not be far above freezing by the end of the winter heating season.

Where available, moving water or large bodies of still water may be used as a heat source. A range of water source systems are available. Closed loop systems may draw heat from moving water in streams or rivers, or from lakes, passing antifreeze mixtures through pipes which are warmed by the surrounding water. Open loop systems may use a pair of wells, drawing water from one and discharging to another. Heat may then enter the system by the movement of water through the aquifer, and by the conduction of heat through the surrounding rocks.

In the Bakewell Town Hall case, it is hoped that it will be possible to harness an 'off the shelf' open loop water source heat pump to meet as much of the space heating needs of the building as possible, though this is contingent on the available spring water source being large enough to deliver the necessary thermal energy. If this is not large enough to meet the heat requirements of the building fully, a heat pump might still be used to meet much of the heating need, with another heat source, perhaps a gas boiler, available for occasions when spring water flow is low, or heat demand is exceptionally high.

A heat pump system might also contribute to 'domestic hot water' (DHW) heating, though the temperature delivered may not be high enough to ensure control of Legionnaires' disease. A small gas boiler or immersion heaters might be used to eliminate any risk of Legionella build up. Some heat pumps integrate any necessary electric heaters into the same housing as the heat pump.

6 - Assessing Building Heat Requirements

In all probability, DHW heating will only account for a small proportion of the buildings energy use. As such the design of the heating system will focus on space heating requirements.

Historically the sizing of heating systems has been an add-hoc affair. Ideally the peak heat demand would be established by calculating the heat losses from the building under the coldest conditions agreed with the client to be likely to be encountered, and the annual energy consumption would be measured and an assessment made based on historical data and the local climate, number of 'degree days' etc. Despite the availability of these rigorous methods, many systems are installed with two or three times the necessary capacity.

To comply with UK legislation which implements the Energy Performance of Buildings Directive (EPBD), the Trust may be required to show an Energy Performance Certificate (EPC) / Display Energy Certificate (DEC) from October 2008. The calculations which allow this assessment to be made might also give clues to the heat demand of the building, though the underlying Simplified Building Energy Model (SBEM) is not primarily intended as a design tool, and should not be used for system sizing.

The gas boiler itself gives clues to the heat that might be consumed on site, but as this has a modulating burner and may be run at any duty cycle, it only places an upper limit on the amount of energy that might be consumed.

In the absence of in depth studies of the building fabric or detailed logs of energy consumption and distribution within the building, it will be assumed that the gas consumption indicated in section 3 of this document may give the best indication of the amount of energy required for space heating in the building. Taking boiler efficiency into account, on a typical winter day, it appears that as much as 650 kWh of energy may be required per day, with exceptionally cold days perhaps using as much as 1,000 kWh. Were this boiler to run at full power for twelve hours, it would deliver 2064 kWh which is consistent with the assessment based on the buildings gas consumption and the above remarks about overcapacity.

For the purposes of assessing the viability of heat pump systems, it will be assumed that the heating will be run for up to twelve hours per day in winter, allowing three hours to warm the building prior to a nine hour working day.

Over a twelve hour daily operating period, 650 kWh would require a constant power input of a little under 55 kW, while 1,000 kWh would require a little over 83 kW.

7 - Assessing Spring Water Energy Resources

The amount of energy available from a stream of water depends on the specific heat capacity of water, the flow rate and the amount by which it can be cooled by the heat pump.

The specific heat capacity of water can be assumed to be fixed, and the amount water can be cooled by is constrained by the requirement that the water must never be permitted to cool to the extent where there might be risk of freezing at cold spots within the heat pump heat exchanger. Many heat pumps also have a maximum amount by which they can cool water, typically 4°C to 6°C.

A spreadsheet has been provided with this report to facilitate exploration of any spring or other fixed temperature water source as a resource for water source heat pumps. This .xls file will run on Microsoft Excel 2000, but should this not be available, it works just as well on the OpenOffice.org Calc program which is part of the Open Office suite. This very excellent open source software is available as a free download from the http://www.openoffice.org/ web site.

It is envisaged that the first page of the spreadsheet will generally be used to see if the spring water resources available can meet the energy demands of a building on winter days.

This takes data entered in the blue shaded cells of the spreadsheet, and derives a number of results. Subsequent rows are colour coded as follows.

> Green lines are constants. Note however that as the fuels burned to generate electricity in the UK change over time, the figure for carbon dioxide emitted per kilowatt hour of electricity used may require adjustment. At the moment it is rising sharply as coal is being substituted for natural gas in the 'UK generating mix' as natural gas prices rise. The accepted figure has gone from 0.43 to 0.52 kg of carbon dioxide per kWh of energy delivered in the last year.
>
> Yellow lines are intermediate calculated results which may be of interest.
>
> Red lines are significant outputs that you'll need to know to size your system or negotiate with external agencies.
>
> Brown lines refer to the emissions and cost performance of an alternative (or existing) heating system and fuel, based on the delivery of the same amount of thermal energy as the heat pump.

Note that all significant numbers are shown in the column B of the spreadsheet. Selecting cells in this column will show the values or formulae that calculate cell values near the top of the spreadsheet window.

The core calculation takes the spring source temperature and the temperature at which the heat pump will discharge cooled water. This quantity, sometimes referred to as 'delta T', written as ΔT, is multiplied by the thermal capacity of water (4.187 kJ per litre per degree centigrade), and the number of litres of water flowing from the source per second, to give the amount of power available from the spring water when the heat pump is running (not including the electrical input). The amount of power available is used to calculate the amount of energy that might be available per hour. The number of hours per day that heating will be required (the daily operating period) is input by the user so that the amount of energy that might be extracted from spring water per working day can be calculated. This ignores the possibility of storing water for later use when the heat pump is not required. Project developers might consider this, but note that the volume of storage required may be very significant.

The number of cubic meters of water per day is calculated by the spreadsheet. This figure may be requested by the Environment Agency who may require the purchase of a water Abstraction License.

The COP of the heat pump may be input by the user. This figure, typically in the range 3 to 8 for warm water source systems, will depend on the properties of the heat pump, particularly the difference between the heat source and sink temperatures. This figure should be taken from tables or graphs provided by the heat pump manufacturer. If a manufacturer is reluctant to discuss the COPs of their products, be very suspicious, and ask how performance can be assessed and compared with other products. Entering the COP for the conditions under which the heat pump will be working into the spreadsheet allows the amount of electricity that will be used to extract the energy from the spring water to be calculated. This in turn allows the calculation of the total amount of energy available to the heat sink (building), and the cost of delivering that energy.

The carbon emissions arising from the use of the heat pump are also calculated to allow the environmental benefit of using the heat pump to be assessed.

The estimated performance of the heat pump can be compared with alternative fuels by entering the cost and carbon emissions per kilowatt hour for the selected alternatives. This facility may also be used to compare the use of a heat pump to existing heating systems.

On the following page of the spreadsheet, annual figures are estimated. These are based on the assumption that the figures entered on the first page refer to a typical winter day, and that consumption on a typical winter day will be twice that of the year round average consumption. This is however only intended to give a very crude estimate of a years consumption, provided to give an 'order of magnitude' idea of likely performance. These results should not be used to prepare budgets or calculate operating costs.

8 - Off The Shelf Heat Pump Options

A number of manuafacturers have water source heat pumps available. Care must be taken to ensure the spring water supply is compatible with the machines considered.

Water Quality Issues

Amongst other things, the mineral content, chloride ion concentration, and pH of the spring water should be checked by analysis to ensure compatibility. If the necessary water quality cannot be met directly by the spring water, an intermediate heat exchanger might be used between the spring water and the heat pump. This has the disadvantage that the temperature of water available to the heat pump will be reduced. This in turn will reduce the COP. A benefit however, might be that a greater range of heat pumps may be available as it may be possible to use some machines intended for ground source operation. These however are likely to require the use of a glycol based antifreeze in the pipes between the heat exchanger and the heat pump, if only to honour the warranty. Any heat exchanger should be used in a contraflow configuration (see Appendix 1) to minimise the temperature drop between the spring water and the water / antifreeze mixture circulating between the heat exchanger and heat pump.

Water Temperature and Flow Issues

Most heat pumps have a heat source upper temperature limit. One manufacturer has suggested a figure as low as 15°C, though 20°C to 25°C may be more typical. Some of the springs in the Peak District may thus approach or even exceed the source upper temperature limit of some heat pumps.

It may be possible to achieve the necessary inlet temperature by diluting the incoming warm water with discharged cold water from the heat pump. In theory this might be achieved with a 'three port thermostatic mixing valve'. While this type of valve is available for undrfloor heating systems with an outlet temperature range of 20°C to 40°C, this will have to be able to achieve the necessary flow rate, and a number of valves might need to be operated in parallel to meet this requirement.

Another approach might be to mix spring water and cold discharged water in a tank prior to the heat pump using electronic thermostatic controls. This might allow the optimisation of the water flow and temperature to get the best possible COP from the available stream flows and temperatures.

The mixing of spring water and water discharged by the heat pump may also be appropriate where the flow of spring water alone is inadequate. This water reuse must not reduce water at the water source inlet of the heat pump below the minimum temperature permitted by the manufacturer. This technique will be of more use with limited flows, but higher stream temperatures.

Electrical Issues

As a general rule, heat pumps with heat outputs larger than 10 to 15kW require a three phase electrical supply. Although the electrical requirements of a heat pump may be relatively modest while it is running, the 'switch on surge' current may impose severe stress on electrical systems.

As an example, a small single phase heat pump with only 1.2kW thermal output that draws a current of 1.66 amps when running, might draw a switch on surge current of over 90 amps for less than a second as it is switched on. As most domestic electrical supplies are fused at 60 or 100 amps single phase, larger machines require the use of either three phase power supplies or 'soft start' motor technologies.

Soft start technologies include mechanical, hydraulic and electrical techniques. One of the most beneficial is electronic inverter drive which also allows variable speed of the heat pump motor. This also offers the possibility of continuous modulated operation with variable heat output from a heat pump rather than controlling energy output by simply switching the machine on and off. Where multiple heat pump compressors are installed, it is normal practice to start them a few seconds apart to reduce the peak current requirement.

Before installing a heat pump system, it is advisable to contact the local electricity District Network Operator (DNO) to ensure that the local electricity distribution system can withstand the peak and continuous loads associated with the starting of heat pumps.

Other System Design Issues

For larger systems it may be necessary to use more than one heat pump. Even where it is not necessary to use more than one heat pump, some designers and users of systems may choose to do this in order to reduce the number of 'single points of failure' in a system. Two smaller heat pumps may cost more than one larger unit with the same total power however, and the system controls will also be more complex as they will need to include load sharing and sequencing capabilities to ensure even use of all the installed pumps.

Where multiple heat pumps are used, ideally they should be connected to the spring water supply in parallel to work at the highest possible heat source temperature. Where the available flow rate does not permit this, the spring water may sometimes be passed through two heat pumps 'in series' as long as the last heat pump has an inlet temperature that exceeds the minimum required by the manufacturer.

In general it is possible to make heating systems that use a heat pump and another type of boiler, for example a natural gas unit. These may be of use, either in situations where a heat pump can meet the thermal demand most of the time and the capital cost of a second or larger heat pump would be disproportionate to the benefit, or to situations where the spring heat source may not be adequate at all times of year and some backup is necessary, even if the operating fuel cost is higher. Note that condensing gas boilers may work more efficiently than usual at low system temperatures. This is because the exceptionally low return temperatures found in systems based around under floor heating (UFH) for heat pumps may facilitate more efficient condensing of water in the combustion gasses. Discuss this with your proposed suppliers when evaluating gas boilers for integration into heat pump systems.

When a heating system uses radiators and a heat pump, the efficiency of the heat pump depends critically on the radiators operating at the lowest possible temperature. In retrofit situations where a building has operated with radiators heated by other means at higher temperatures, it may be necessary to add more radiators to emit the same amount of heat at a lower operating temperature. The use of fan assisted radiators may be useful in these situations.

Where high temperature boilers are used to heat water for underfloor heating systems, it is common practice to use a three port thermostatic mixing valve and a circulating pump to deliver large flows of water at a constant but lower temperature. While the large flow rate is always desirable to help achieve a uniform temperature distribution over the whole floor area, where heat pumps are used to power UFH, the regulation of temperature by dilution with water from the UFH return is undesirable as it is predicated on the assumption that the heat source produces water at a higher temperature than is required in the floor that it is heating. Where a heat pump is used, greater system efficiency is achieved with a good flow rate through the under floor heating, but without restricting the temperature with a three port mixing valve. Further, it may be desirable to install the under floor heating pipes closer together when powered by heat pumps, perhaps on 150mm to 200mm centres rather than on 300mm centres. The floor may then be heated with water at a slightly lower temperature. This gives the same heat output, a more uniform floor slab temperature, and allows better heat pump efficiency to be achieved.

Note that if the demand for heat may be significantly less than the output of the heat pump, a buffer tank (heat store) may be required to add thermal capacity to the heat distribution system. This is simply a direct cylinder. Where these heat stores are large, they may allow the storage of heat extracted from stream water using low cost electricity over night, though if this is to make a substantial contribution to a buildings space heating requirement, these heat stores may need to be very large indeed.

As an example, let us now consider two manufacturers heat pumps with water inlet temperatures of 11.6°C, 15°C and 25°C, driving either under floor heating at 35°C, or radiators at 50°C.

Example 1 - Use of a Stiebel Eltron WPW 44 Pump

The WPW 44 water source heat pump is a relatively new addition to the Stiebel Eltron heat pump range. It follows the WPW 7, WPW 10, WPW 13, WPW 18 and WPW 22 units. These all have the same external appearance similar to the housing displayed on the opposite page. The WPW 44 comprises two WPW 22M units which are run next to each other as a single device, see picture on page 22. The WPW 22M is similar to the WPW 22, but lacks some of the internal control equipment which is required when running as a stand-alone unit.

WPW 44 units can be used in groups, so a pair of WPW 44 units would offer twice the heat output, but require twice the water source, and twice the electrical energy input.

The 11.6°C To 35°C Case

Let us now use the spreadsheet to consider how the WPW44 heat pump might operate from an 11.6°C spring water source. Enter the following into the spreadsheet,

set the "Spring water inlet temperature:" value field shaded blue to 11.6 .

The amount a WPW44 can cool heat source stream water is typically 4°C to 6°C. Taking 5°C as an average,

set the "Heat pump water outlet temperature:" value field shaded blue to 6.6 .

Now enter the measured or expected available source water flow rate.

Set the "Spring water flow rate:" value field shaded blue to 4.9 .

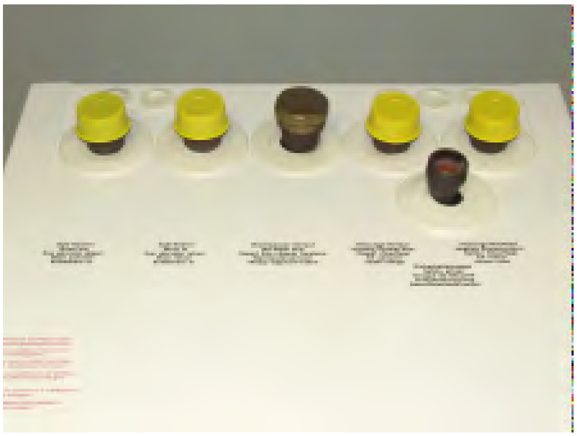
This figure is a fraction over the minimum permitted flow rate for these machines. Next select the number of hours per day heating will be required including any warm up period prior to use. Twelve hours is typical for office or school buildings, so

set the "Hours per day winter heating required:" value field shaded blue to 12 .

Now set the heat pump COP figure for the spring water source temperature and the required heat sink temperature. This will need to be looked up from graphs or tables provided by the manufacturer for each set of temperatures. For this heat pump, for spring water at 11.6°C and under floor heating at 35°C,

set the "Heat pump COP:" value field shaded blue to 6.3 .

Enter your electricity cost in pounds per kWh. As an example you might use £0.085



A typical Stiebel Eltron heat pump housing.

Top left picture, the plumbing connections, back row from left to right, heat source water out, heat source water in, hot water flow to DHW cylinder or calorifier, space heating flow, and return shared between space and water heating. The pipe to the front is connected to internal safety devices.

Top right picture, connections and control electronics.

Bottom left picture, the casing as seen from the outside.

Bottom right picture, inside the unit, the compressor module (large black cylinder), insulated pipes and soundproofing foam.

Above, a Stiebel Eltron WPW44 heat pump installed in a plant room with a buffer tank (heat store).

per kilowatt hour (kWh), though all prices suggested here will soon be out of date.

Set the "Unit electricity cost:" value field shaded blue to 0.085 .

The next three figures are used to allow comparisons between the heat pump scenario already specified, and some existing or alternative heating system. As an example, you might want to compare with a natural gas boiler, so

set the "Alternative fuel cost:" value field shaded blue to 0.04

or what ever you gas costs per kWh. Next set the weight of carbon dioxide emitted per kWh delivered by the alternative fuel. These values may be obtained from the DEFRA web site for a range of fuels. For natural gas,

set the "Alternative fuel emissions:" value field shaded blue to 0.19 .

Finally set the alternative fuel boiler efficiency. For condensing boilers this will typically be in the range 87% to 96%, for non-condensing boilers, typically 60% to 80%. For a typical condensing gas boiler,

set the "Alternative boiler efficiency:" value field shaded blue to 92 .

On the red rows below, the daily carbon dioxide emissions, operating costs and available energy are then shown,

> 130.1 kg per day
> £19.74 pounds spent per day
> 1,463.2 kWh per daily operating period

and on the brown lines immediately below, the performance of the existing or alternative heating system is shown for the same energy output. The second page also indicates crudely estimated figures for a year of operation, giving the mass of emitted carbon dioxide, projected operating cost, and energy delivered.

> 23,737.0 kg per year estimated
> £3,602.93 pounds spent per year
> 267,040.9 kWh delivered per year .

Note that with these inlet temperatures, the spring water would have to be split so that the two WPW44 heat pumps could operate in parallel, as the water discharged from either heat pump would be too cold to safely feed the other heat pump with their inlets 'in series'.

The 15°C To 35°C Case

To obtain figures for operation from a 15°C spring water source, simply look up the COP of the heat pump when operating from a 15°C source powering a 35°C load, and make the following changes,

> set the "Spring water inlet temperature:" value field shaded blue to 15 ,
> set the "Heat pump water outlet temperature:" value field shaded blue to 10 ,
> and set the "Heat pump COP:" value field shaded blue to 6.8 .

This then gives the results

> 118.9 kg per day
> £18.04 pounds spent per day
> 1,443.2 kWh per daily operating period

and very roughly,

> 21,690.7 kg per year estimated
> £3,292.34 pounds spent per year
> 263,386.8 kWh delivered per year .

Note that with these inlet temperatures, it has been assumed that the spring water would be split so that the heat pumps could operate in parallel at the best temperatures, though if flow rate from the stream was limited, the water discharged from the first heat pump would be warm enough to safely feed a second heat pump in series at an inlet temperature no lower than 9°C, though the second heat pump would operate at a lower COP.

The 25°C To 35°C Case

Considering a 25°C spring water source, a complication arises as the maximum sustained source water inlet temperature to the WPF44 is 20°C. Additional plant will be required to dilute water discharged by the heat pump into the water from the stream to sustain operation within the permitted operating temperature range. Basing our calculation on operation from a 20°C source then, look up the COP of the heat pump when operating from a 20°C source powering a 35°C load, and make the following changes to the spreadsheet,

> set the "Spring water inlet temperature:" value field shaded blue to 20 ,
> set the "Heat pump water outlet temperature:" value field shaded blue to 15 ,
> and set the "Heat pump COP:" value field shaded blue to 7.4 .

This then gives the results

> 107.7 kg per day
> £16.35 pounds spent per day
> 1,423.3 kWh per daily operating period

and very roughly

> 19,657.2 kg per year estimated
> £2,983.68 pounds spent per year
> 259,755.6 kWh delivered per year .

Note that with these inlet temperatures, it has been assumed that the spring water would be split so that the heat pumps could operate in parallel at the warmest temperatures, though if flow rate from the stream was limited, the water discharged from the first heat pump would be warm enough to safely feed a second heat pump in series at an inlet temperature no lower than 14°C. Indeed, were a site such as this to have a higher heat demand but limited flow rate, a third WPW44 heat pump could be added in series with an inlet temperature of no less than 8°C.

At this point it is worth noting some trends. For a given flow of spring water,

- as the source temperature increases the COP increases, and
- as the source temperature increases the electricity cost falls.

Let us now consider a system heating radiators at 50°C. ***This situation is likely to be similar to Bakewell Town Hall.***

The 11.6°C To 50°C Case

In the spreadsheet,

set the "Spring water inlet temperature:" value field shaded blue to 11.6 ,
set the "Heat pump water outlet temperature:" value field shaded blue to 6.6 ,
and set the "Heat pump COP:" value field shaded blue to 4.4 .

This then gives the results

202.7 kg per day
£30.77 pounds spent per day
1,593.0 kWh per daily operating period

and very roughly

37,001.8 kg per year estimated
£5,616.34 pounds spent per year
290,728.0 kWh delivered per year .

The 15°C To 50°C Case

In the spreadsheet,

set the "Spring water inlet temperature:" value field shaded blue to 15 ,
set the "Heat pump water outlet temperature:" value field shaded blue to 10 ,
and set the "Heat pump COP:" value field shaded blue to 4.8 .

This then gives the results

181.4 kg per day
£27.54 pounds spent per day
1,554.9 kWh per daily operating period

and very roughly

33,106.8 kg per year estimated
£5,025.14 pounds spent per year
283,772.8 kWh delivered per year .

Note that these two cases are likely to exceed the likely heat demand of Bakewell Town Hall easily, even on the coldest winter days.

The 25°C To 50°C Case

Again, because of the upper source temperature limit of 20°C, in the spreadsheet,

set the "Spring water inlet temperature:" value field shaded blue to 20 ,
set the "Heat pump water outlet temperature:" value field shaded blue to 15 ,
and set the "Heat pump COP:" value field shaded blue to 5.4 .

This then gives the results

156.7 kg per day
£23.78 pounds spent per day
1510.7 kWh per daily operating period

and very roughly

28,592.3 kg per year estimated
£4,339.90 pounds spent per year
275,711.1 kWh delivered per year .

Again it is worth noting some trends. For a given flow of spring water,

- as the source temperature increases the COP increases, and
- as the source temperature increases the electricity cost falls.

Note however that all the COP figures are lower when heating radiators at 50°C than they were warming under floor heating at 35°C.

Note also that while the WPW44 can run radiators at 60°C, the COP values from 11.6°C, 15°C and 25°C source temperatures would be much worse, respectively 3.4, 3.7 and 3.9 . The COPs are summarised below.

	35°C UFH	**50°C rads**	**60°C rads**
Source 11.6°C	6.3	4.4	3.4
Source 15°C	6.8	4.8	3.7
Source 25°C (20°C)	7.4	5.4	3.9

Given these values, the heat sink (building emitter / radiator) temperature should not exceed 50°C if at all possible.

The list price of the WPW44 is £9920 + VAT each. Unless a boiler was used to provide additional heat on cold days, two WPW44 units would be required at Bakewell Town Hall costing £19,840 + VAT at applicable rate, 5% or 17.5% depending on the type of project. This excludes work in the plant room, connection to the heat sources, gaining access to the heat source water and any necessary pumps.

Example 2 - Use of a Glen Dimplex WI 40CS or WI 90CS Pump

Dimplex make two water source heat pumps that might be appropriate for the Bakewell Town Hall site. Two WI 40CS, or a single WI 90CS units might be used. For the purposes of this document the use of a single WI 90CS will be examined. The use of WI 40CS units might offer advantages of fault tolerance, but would take up more space in the plant room for the heat pumps, and would require more plumbing, controls, and capital spend. This option should however be considered at the detailed design stage.

The WI 90CS has a maximum inlet temperature of 25°C which might be an advantage at the higher spring temperature sites in the Peak District, but has a minimum water source requirement of 5.6 litres per second, a maximum heat source ΔT of 4°C, and a maximum output temperature of 55°C. COP data for operation at 60°C is thus not available. Information provided by the manufacturers indicates the following COP figures.

	35°C UFH	**50°C rads**
Source 11.6°C	5.5	3.9
Source 15°C	5.8	4.5
Source 25°C	6.5	5.3

Using the spreadsheet as before, with the water source flow rate set to 5.6 litres per second (a little over the minimum specified by the manufacturer), a heat source ΔT of 4°C, and COP data for the WI 90CS for the same heat source and sink temperatures that were considered for the WPW 44 machines, the following results are obtained.

The 11.6°C To 35°C Case

Estimated daily results

140.1 kg per day
£21.26 pounds spent per day
1,375.6 kWh per daily operating period

and very rough annual results,

25,560.6 kg per year estimated
£3,879.73 pounds spent per year
251,041.4 kWh delivered per year .

The 15°C To 35°C Case

Estimated daily results

131.3 kg per day
£19.93 pounds spent per day
1,359.9 kWh per daily operating period

and very rough annual results,

23,963.0 kg per year estimated
£3,637.25 pounds spent per year
248,188.6 kWh delivered per year .

The 25°C To 35°C Case

Estimated daily results

114.6 kg per day
£17.39 pounds spent per day
1,330.1 kWh per daily operating period

and very rough annual results,

20,913.2 kg per year estimated
£3,174.32 pounds spent per year
242,742.5 kWh delivered per year .

The 11.6°C To 50°C Case

Estimated daily results

217.3 kg per day
£32.99 pounds spent per day
1,513.6 kWh per daily operating period

and very rough annual results,

39,663.0 kg per year estimated
£6,020.27 pounds spent per year
276,224.2 kWh delivered per year .

The 15°C To 50°C Case

Estimated daily results

180.1 kg per day
£27.33 pounds spent per day
1,447.0 kWh per daily operating period

and very rough annual results,

32,863.6 kg per year estimated
£4,988.22 pounds spent per year
264,082.5 kWh delivered per year .

The 25°C To 50°C Case

Estimated daily results

146.6 kg per day
£22.25 pounds spent per day
1,387.2 kWh per daily operating period

and very rough annual results,

26,749.4 kg per year estimated
£4,060.18 pounds spent per year
253,164.3 kWh delivered per year .

Looking at the trends in output power for a given amount of heat extracted from water by the WI 90CS, it can be seen that as the inlet temperature increases, the COP improves, but the amount of output power falls slightly. This is because less electrical energy is needed to extract the heat from the water. This improvement in the in the ratio of heat coming from spring water and purchased electricity is consistent with, indeed the cause of, the lower operating costs as the gap between the heat source and sink temperatures narrows.

It is also interesting to compare the outputs of the Stiebel Eltron WPW44 machines and the Glen Dimplex WI 90CS for given input and output temperatures. Although the WI 90CS delivers a little more heat output for a given amount of heat extracted from spring water, this is again due to the use of more electricity per unit of heat delivered (slightly poorer COP values over the range of temperatures examined). This is not an indicator that the WI 90CS operating cost will be lower.

The 'standard price' of the WI 90CS is £15,998.93 + VAT at applicable rate, 5% or 17.5% depending on the type of project. This excludes work in the plant room, connection to the heat sources, gaining access to the heat source water and any necessary pumps.

9 - Bakewell Site Hydrology

This document has worked through examples of an approach to determining the initial feasibility of spring water source heating systems, but any practical use of water source heat pumps depends on there being an adequate supply of water at a temperature that makes its use economically viable.

An article from the Peak Advertiser dated the 24th of November 1997 entitled "The Secrets Of Bakewell Bath House" (© Julie Bunting 1997), gives a number of clues to the status of the Bakewell Bath House springs.

It suggests that there is evidence of activity on the site related to the spring going back eight hundred years and possibly further, and that the 1637 well at the bath was constructed below ground level, the bath being fed by natural springs. It seems clear that there were at least two springs on or near the site, one warmer than the other which were permitted to mix, perhaps artesian fossil water, and ground or surface water. Of the temperatures mentioned for the site, 11.6°C and 15°C, it is not clear which temperatures refer to which springs, or to mixtures of water from the springs.

The article relates that "A tolerably constant flow is maintained in winter, but in summer it has a trick of failing, and, when I saw it, the water was not more than two or three inches deep". Flow rate is notoriously hard to judge however. If flow is perceptible in a deep pool or bath, a very considerable number of litres per second are likely to be flowing, and the demand for spring water on the site will be highest in winter, so the availability of spring water may map well onto the demand. Even when no flow was observed in the bath, perhaps because of seasonal variations in the water table, significant amounts of water might have been available had pumps been available to abstract water from a few feet lower down, and it may be the case that water from deeper strata might be warmer. Should this be the case, a borehole might be drilled to the appropriate depth, and lined to exclude surface and ground water. A borehole pump could then abstract water and transfer it to the Town Hall pump room.

A detailed excavation of parts of the site might reveal where the various springs rise or rose. This may require specific consents as the building is listed, but if this work can be undertaken in the spirit of archaeological investigation and restoration of the building, rather than being seen as a mere 'dash for the aquifer', this might be undertaken as a partnership with significant benefits to all stakeholders.

The article also suggests that "Nowadays the water is diverted away from the bath although sometimes in winter a shallow pool collects at the ‘deep end’". If added to the deep end, the use of tracer dies might offer clues as to the path of the diversion.

From the comment "The old water level begins where peeling whitewash gives way to blackened stonework, indicating a gradual increase in depth from about 3’ to 5’", it might be assumed that the level of the water table has fallen, either due to climate change or abstraction at other locations. Knowledge of when the bath was whitewashed might give a clue to the time scale over which this has occurred. The stone lined sough from the deeper end of the bath that runs in the direction of the Royal Bank of Scotland should also be investigated.

It is also noted that "The larger window overlooks the Legion’s Memorial Garden, a quiet reflective corner with a fountain playing in a thermal pond which never freezes over, even steaming slightly on the coldest days of the year". From the tense used in the article it might be assumed that this was still accessible in 1997. If it is still visible at the present time, or its location known, it could be a starting point for tracing access to the available warm water.

An article by George Challenger on The Bath House in 'Bakewell & District Historical Society Journal 2005 No.32' also makes a number of interesting indications. Among these are that there are five warm springs in Bakewell, which perhaps indicates that other buildings may have opportunities to exploit this type of heat source. It also relates that boring for the spring under the perforated stone floor of the bath was not successful in 1909, and that "the cutting of a deep sewage trench along Bath Street about 1937 affected both the quality and flow of the old spring water". It also notes however, comments in an unpublished work by Ted Meeke, 'White Watson: Bakewell's Only Famous Man', that "There was a hot spring at Bakewell and there probably still is but it has vanished into the new sewerage system... ...the late R.W.P. Cockerton stated that a workman had told him that, when working on the school in bath street, he was standing in warm water".

This anecdotal evidence may give clues to the location of the spring and the direction from which warm water approaches the site. In addition to examination of the historical record, a full range of geophysical and hydrological survey techniques might be used to identify where these resources are. Flow rate and thermal studies should then be undertaken to assess the resource available.

While the warm water is of most obvious use to provide energy for space heating, if flow rates are inadequate, the abstraction of cooler water might still be useful.

Should pumped abstraction tests indicate that use of the system would reduce the level of the water table around the site excessively, consideration might be given to discharging water from the heat pump system to a well or borehole near to, but not in the immediate vicinity of the point of abstraction. In effect this would create an opportunity for a contribution of 'open loop ground water source heat'.

10 - Conclusions

This document works through examples of an approach to determining the initial feasibility of sprng water source heating systems.

It should be read in conjunction with the spreadsheet supplied so that the thermodynamic feasibility of a site can be established.

The spreadsheet deals with the energy that thermodynamics predicts might be extracted from a stream of water at a given temperature without taking account of the practical constraints imposed by particular machines. It does not do detailed design calculations which must include parameters specific to each heat pump. These vary from model to model. For example it can take no account of the practical constraints imposed by some products, e.g. minimum flow rates, heat source ΔT values, and switch on surge currents which should be addressed as the detailed design is undertaken.

With regard to the specific case of the Bakewell Town Hall building, it has been assumed that heating the radiators to 50°C will be adequate, though at this temperature it may be necessary to add additional radiators in the cooler parts of the building, perhaps fan assisted, to increase heat transfer rates if 50°C is much lower than the flow temperature of previous heating systems.

From COP information provided by Stiebel Eltron, estimates based on the gas bills from the site, and calculations undertaken using the spreadsheet provided, it seems ***energetically feasible*** that spring water source heating using spring water at 11.6°C can meet the heat demand of a typical winter day, 650 kWh, as long as a flow rate in excess of 1.75 litres per second (152 m3 per day) is available with a heat source ΔT of 5°C. A colder winter day which might require 1000 kWh would require a flow of at least 2.6 litres per second (225 m3 per day to meet the energy requirement). It is vital to note however, that Stiebel Eltron specify a minimum flow rate through the machine of a little under 4.9 litres per second for a pair of these machines to avoid them freezing the spring source water.

From COP information provided by Glen Dimplex, estimates based on the gas bills from the site, and calculations undertaken using the spreadsheet provided, it seems ***energetically feasible*** that spring water source heating using spring water at 11.6°C can meet the heat demand of a typical winter day, 650 kWh, as long as a flow rate in excess of 1.75 litres per second (152 m3 per day) is available. A colder winter day which might require 1000 kWh would require a flow of at least 2.6 litres per second (225 m3 per day to meet the energy requirement). Again it must be noted however, that Glen Dimplex specify a minimum flow rate though their machine of a little under 5.6 litres for their machine to avoid it freezing the spring source water.

Under all conditions it appears that the Stiebel Eltron WPW 44 machines offer slightly better performance, though the heat pumps and control equipment are likely to be more expensive.

It is important that the flow through the heat pump be continuous while it is in operation, and that air not be drawn into the system, risking air locks, interruption of flow and freezing of the heat exchangers. It thus seems worth allowing a contingency of perhaps 50% when estimating the flow rates required. A greater flow rate may also convey some efficiency benefit as the water discharged from the heat pump may be at a higher temperature allowing a slightly better COP to be achieved. If the flow requirements cannot be met continuously in full, it may be necessary to collect water in a local tank and run the heat pump intermittently. This might be integrated with any necessary recirculation of water discharged from the heat pump, though recirculation will reduce the temperature available, and thereby the COP that can be obtained.

In either of the above cases, should it transpire that water is available at 15°C, this will improve the COPs available, reduce the proportion of the energy obtained from purchased electricity, and reduce the operating cost and environmental impact, and possibly simplify the design of the plant.

On the basis of the above analysis it would appear that while the Stiebel Eltron heat pump set is somewhat more expensive than its Glen Dimplex counterpart, it offers better COP values over the range of temperatures considered, requires a little less water, and should extract more heat from a given flow of water.

Compared to heat provided by a condensing gas boiler, it appears that either heat pump would offer significantly lower running costs and carbon emissions.

Based on a typical winter scenario with a heat demand of 661kWh per day, delivered using two WPW44 pumps for five hours during the working day, using water at 15°C to heat radiators to 50°C with a COP of 4.8, if we assume an electricity price of 12p per kWh and a gas price of 6p per kWh, the spreadsheet suggests the following heat pump annual performance,

> 14,076.0 kg per year estimated
> £3,016.29 pounds spent per year
> 120,651.7 kWh delivered per year
>
> 25,470.9 kg CO2 per year
> £8,043.45 pounds spent per day

This suggests that despite the high capital cost of a heat pump system, the running cost might be under half that of a natural gas fired system. As gas imports may cause gas prices to rise faster than electricity prices over the next few years, it might be that this cost differential will grow over time.

Should heat pumps be used for cooling parts of the building in summer, the availability of water at 15°C or less, will allow less energy intensive cooling than the use of warm air on a summer evening. If water levels permit in summer, the borehole facility might be used as a heat sink for cooling equipment as long as this is justified by the energy cost of pumping the cool water out of the ground. Again, this should be the subject of later detailed design to verify that this approach is cost effective and feasible with the use of off the shelf equipment.

11 - What Next ?

Although this study has focused on the equipment needed to heat buildings and the flow rate and temperature of spring water required to do this, no further progress can be made on the Bakewell site until the location of the nearby springs are identified and it is clear that water can be abstracted from them.

As it is know that springs have risen near the surface at a range of temperatures, it is important to identify where the sources are at each temperature, and how much water can sustainably be drawn from each.

Anecdotal information may indicate some known locations of warm ground, and T4 is willing to undertake thermal imaging to examine areas where springs have risen, and the surrounding areas.

Excavation, exploration and thermal imaging of the floor of the bath house and channels linked to it may give further clues, along with any methods hydrologists or geologists can suggest to locate the underground sources from which water might be drawn.

Test boreholes may be sunk, and in the long run, water should perhaps be abstracted from boreholes that tap warm sources of water rather than from the bath house building. This both preserves the building, and offers the possibility that the use of appropriately directed lined boreholes might avoid contamination of the warmest water with other cool or cold sources.

Ideally investigations will involve gaining access to each spring source, and pumping water out for a period of time to determine the level to which the water in the borehole falls as abstraction occurs. The temperature of the abstracted water should be monitored during this process to log the temperature over time, to see if drawing water out of the boreholes brings warmer water up to the surface. It may be that the availability of warm water requires flow up from an artesian at significant depth. It may therefore be important to know the temperature of water that is withdrawn over a sustained period, rather then the temperature of static water in a bore hole that may be a long way from the source of the underground heat. T4 would be pleased to discuss a range of low cost water temperature data logging options.

If resources can be found to identify the hydrological resources, work can proceed to detailed specification which should examine a range of heat pumps from these and other manufacturers, as well as assess the other plant room equipment required.

12 - Possible Funding Opportunities

The next stage of the project is not a simple renewable energy installation, in that the equipment required, and the configuration in which it might be installed, depends on the quantiy and temperature of of water that can be obtained from the springs close to the building.

The next stage is not to install equipment, but to locate and quantify that resource so that the design can be finalised.

It is thus recommended that money is now sought for the following activities.

1) Locate accessible springs and / or aquifers.

2) Undertake test abstractions to ascertain the flow rate at which abstraction can be undertaken, and the temperature of water abstracted.

3) Undertake detailed design of the boreholes, pumps and pipework required to collect water from the spring / aquifer to the plant room, and if necessary, pipework and boreholes required to return discharged water to the aquifer.

4) Select the the most appropriate heat pump, and using the information obtained about the spring water flow rates and temperatures available, design the plant room equipment required to manage the heat source water, including any necessary storage of spring water, reuse of discharged cold water, and the associated control systems.

5) Identify the heating control requirements of the building, and if necessary identify the specification any necessary buffer tank.

6) Confirm that the necessary equipment can fit in the plant room.

Peak District National Park Authority Sustainability Fund

For this add hoc work, the Peak District National Park Authority Sustainability Fund might be able to make a contribution as the projects it funds are not tied to particular activities, processes or types of equipment. Officially the following may be funded,

> "...development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs",

which the site simplifies to,

> "...developing and testing practical sustainable ways of living in and around the

> Peak District National Park now and in the future".

This phase is certainly "developing and testing". For more information, see the following.

> http://www.peakdistrict.gov.uk/sdf

Only once this phase of resource identification and specification has been completed will it be appropriate to attempt to secure resources from funding bodies that require the hardware to be funded to be known in advance.

Low Carbon Buildings Program

Once it is clear what equipment might be installed, it is tempting to expect that a bid might be made for funds under **Phase 2 of the Low Carbon Buildings Program**. This scheme covers

> "Grants for the installation of microgeneration technologies are available to public sector buildings (including schools, hospitals, housing associations and local authorities) and charitable bodies".

Web page

> http://www.energysavingtrust.org.uk/housingbuildings/funding/lowcarbonbuildings/

implies that the LCBP includes support for Water/air source heat pumps. To clarify however, Julia Thomas, Administrator for the Low Carbon Buildings Phase 2 at the BRE, confirms that "Under Phase 2 (not for profit organisations) we do not cover Water or Air source".

In any case the scheme is complex, requiring that the equipment installed is approved under the scheme, and requiring work to be undertaken by 'framework suppliers'. For more information, see the following link.

> http://www.lowcarbonbuildingsphase2.org.uk/

E.On Source Fund

The E.On Source Fund may offer useful funding for renewable energy projects. This is a web based resource that offers funding to sustainable energy projects, and advice on ways to improve the ways in which energy is produced and used.

Community groups, charities and not-for-profit organisations are invited to apply for grants of up to £30,000 to implement sustainable energy projects in their buildings.

Organisations that might apply include schools, local and national charities, special education colleges and wildlife parks.

Use of funds by eligible projects must meet the following criteria.

- Result in the creation of renewable energy and / or a reduction in the amount of energy used.
- Have a positive impact on the local community.
- Have a measurable positive impact on the local environment which will most likely be demonstrated through carbon savings.
- Be used for purchase and implementation of capital equipment, physical measures and associated costs.
- Involve and / or have consent from their local community.
- Be sustainable beyond the support of the Fund.

Priority will be given to projects that can be completed within 12 months of application. For more details, see

http://www.eon-uk.com/source.aspx

Polden-Puckham Charitable Foundation

The Polden-Puckham Charitable Foundation is a trust that awards grants to support change in order to help promote new ideas in peace, security, conflict resolution, and environmental sustainability, to engender values that foster harmony and respect between people and planet.

Areas of interest include work which tackles the underlying pressures and conditions leading towards global environmental breakdown, and particularly initiatives which promote sustainable living.

Exclusions include study, academic research, capital projects such as building works or the purchase of nature reserves, and community or local projects (except innovative projects for widespread application). It is a premiss of this paper that the Buxton Town Hall project could be the first of a number of 'warm spring water source' projects. Care may need to be taken however, to find aspects of the project which the foundation might be willing to fund. More details may be found on the following web site.

http://www.polden-puckham.org.uk/

Biffaward - Main Grants Programme (Amenities)

Financial assistance is available for community projects located within the vicinity of a Biffa operation. This funding source might be pursued if this requirement is met. Supported projects focus on improving quality of life and fostering vibrant communities. The maximum grant value £50,000.

In 1997 Biffa Waste Services agreed to donate landfill tax credits to the Royal Society for Wildlife Trusts (RSWT) to administer under the fund name Biffaward. The principle of sustainability and sustainable development is at the centre of Biffaward's strategy with specific focus on improving quality of life and fostering vibrant communities. Biffaward will do this by supporting projects that provide and improve public amenities. The main aim is to provide and improve community facilities to act as mechanisms for recreation, lifelong learning and community involvement. Projects which fall under this description will be registered under ENTRUST objects D or E. Priority will be given to projects that seek to innovatively expand the use of existing facilities to address a community need e.g. a drop-in café, providing internet access or a museum education room for use by the community.

Eligible organisations are Environmental Bodies enrolled with ENTRUST. All projects must be within ten miles of a Biffa Waste Service operation (there is a proximity checker on the Biffaward website). The budget must be accurate, offering value for money, and matched by realistic income projections.

Preference is given to applicants that have a third party able to provide the 10% necessary to release the landfill tax credits. Evidence of community involvement will be mandatory.

Biffaward will not support feasibility studies, option appraisals or development studies. For more details, see the following URL.

http://www.biffaward.org/

Landfill Communities Fund - Lafarge Aggregates

Financial assistance is available for community and environmental projects carried out near landfill sites in Derbyshire. There is no fixed grant amount. Typical grants are normally between £2,000 and £10,000. The Derbyshire Environmental Trust (DET) was set up by Derbyshire County Council to seek funds from landfill operators to support eligible projects across the county. Funds are distributed on behalf of Lafarge Aggregates for projects in the vicinity of their operational sites at Whitwell, Buxton, Derby, the Trent Valley and across the east/west Midlands, Yorkshire and Durham). The scheme aims to support community and environmental projects which might include improvements to community buildings, play areas, footpaths, restoration of historic buildings etc. Projects must be located in the vicinity of a Larfarge Aggregates operational site. Contact DET for an application pack and further information. For more details, see the following URL.

http://www.derbyshire.gov.uk/community/lottery_funding/environmental_trust/

The Dennis Curry Charitable Trust

Mostly funds charitable organisations with a particular interest in conservation, the environment and education. Grants in the range £500 to £20,000.

Phone 020 7240 9971.

CEMEX Community Fund

Maximum Value: £ 15,000

The CEMEX Community Fund aims to support sustainable local community and environmental projects in the vicinity of a CEMEX operation, usually within ten miles. A full list of CEMEX sites is available on the website. Funding is available for the following.

- Projects which provide or improve community facilities.
- Projects which deliver biodiversity conservation for UK species or habitats.
- The restoration or repair of buildings of architectural or historical interest.

Applicants must be enrolled as an Environmental Body with Entrust, the Regulator of the Landfill Tax Credit Scheme.

Projects must be registered with Entrust by the applying organisation, register under object D, Da or E of the Landfill Tax Regulations, have sustainable long-term management arrangements and demonstrate good community involvement / partnership approach.

Preference will be given to projects that have 0% administration costs demonstrate that sustainability has been taken into consideration (e.g. use of sustainable resources, ecological design), address social inclusion and accessibility, do not require part funding, and do not continue beyond three years. Administration costs must be less than 10% of the total project cost. Projects that have already applied for funding but have been unsuccessful and project extensions will not be considered. Contact the CEMEX Community Fund for further information.

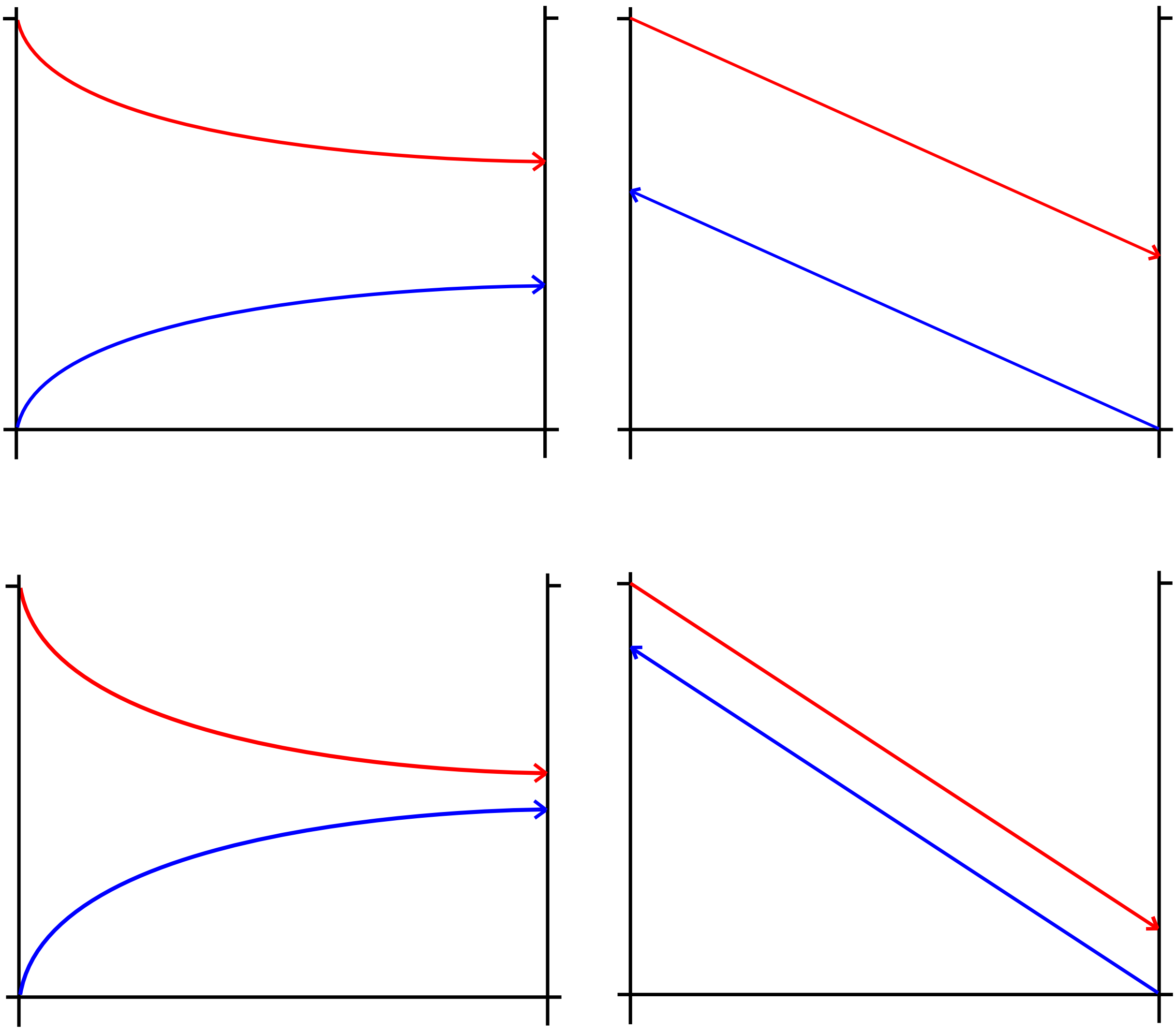
http://www.rmccf.org.uk/index.php

Appendix 1 - Contraflow Heat Exchange

In a 'contraflow' configuration, the fluids between which heat is being transferred pass in opposing directions. This is much more efficient, as the heated fluid leaving the heat exchanger can attain a temperature very nearly as high as heating fluid where it enters the heat exchanger.

The graphs below indicate the relative performance of better (bottom row), and worse (top row) heat exchangers, used in parallel flow (left column), and contraflow (right column) configurations. The y axis indicates temperature, and the x axis indicates location within the heat exchanger. The arrows on the lines indicate the direction of fluid flow.

While it is important to use a good quality and adequately sized heat exchanger, parallel flow, (both fluids passing the same way), will greatly limit the performance that can be attained.



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