Is Steam a Modern Heating Medium or a Victorian Hangover?

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Abstract

In the UK many hospitals use steam as a heating medium. It is an accepted fact that steam can carry considerable amounts of heat energy, but is heating by steam really a cost effective and energy efficient method for hospital engineering services?

This paper examines some steam and MTHW case studies in terms of energy and operation, and some quantifiable parameters for comparison of the two have been obtained. An important feature revealed by the study is that optimum energy and operational performance for both steam and MTHW systems is directly related to management and maintenance.

Other factors affecting the choice of steam are also examined. For example, when choosing between steam and MTHW, how important a factor are those unique hospital applications such as laundries and sterilization equipment, that are traditionally provided for by steam? Interviews were conducted with engineering professionals at a large North-West hospital in order to consider the specialist health service applications for steam.

The investigation concludes that although steam retains a Victorian image, in hospital applications its energy and financial performance costs are comparable, and sometimes better than hot water alternatives.

1.0 Introduction

Steam has for many years been used for the conveyance of heat energy within hospitals. It is often required for such processes such as autoclaves, food preparation and laundry, and it may then subsequently be used for space heating and domestic hot water heating. Steam tends to have a Victorian image, yet it is still often required in modern facilities and applications. For example, it is likely that steam will be the major energy medium for the new Royal Liverpool Hospital, and a well-established steam installation is used in New York City's district heating scheme.

This paper seeks to question whether steam actually is a modern, efficient and effective energy medium, or whether it is used simply because of custom and practice. This is achieved by analysing the performance, energy efficiency and maintenance implications of steam in building services applications in NHS buildings and comparing this with the use of medium temperature hot water (MTHW) systems.

The case studies selected for examination are:

- The Royal Derby Hospital – New MTHW system
- University of Manchester Wythenshawe Hospital – Installation of mechanical condensate recovery pumps
- University of Manchester Wythenshawe Hospital – Replacement of a steam to hot water calorifier with a steam to hot water plate heat exchanger

2.0 Essential differences between steam and MTHW systems

It is self-evident that steam and hot water systems are dissimilar since they utilise different heat transfer media. What is less obvious is that the method of heat transfer in each is also different.

Unlike hot water, heat transfer from steam does not rely solely upon temperature difference. When steam transfers its heat to a lower temperature surface, it condenses and releases its latent heat of vaporisation. A glance at thermodynamic property tables will reveal that low pressure steam contains a greater quantity of latent heat than higher pressure steam. Higher pressures, however, are favoured in the design of systems since they allow distribution pipework to be smaller. Equipment that utilises steam typically requires it at low pressures and it is therefore common practice to install pressure reducing valves at strategic locations on steam systems.

The layout of steam systems must necessarily differ from MTHW systems, although the philosophy of providing a circuit containing flow and return pipes is common to both. The flow and return pipes in a hot water system of course contain hot water at different temperatures, whereas in a steam system the flow pipes distribute steam while the return pipework must accommodate condensate. The process of returning this condensate is an important factor in system efficiency.

The way in which each system distributes its heating medium is also rather different. Steam is distributed by pressure generated at the boiler, whereas hot water is generally pumped. Condensate may be returned to the hot-well by system pressure, though it is common practice to incorporate pumps and receiver vessels in the system.

The method of pressurising steam systems also differs from hot water systems. Steam boilers generate pressure by applying heat within a closed vessel, whereas the pressurisation of hot water systems is more complex. Often supplementary equipment such as specialist boilers, gas filled vessels, pumps and expansion tanks are required. Furthermore, temperature is controlled differently. Hot water systems utilise a mixing arrangement, where the cooler return water is mixed with the flow water, whereas steam systems can exploit the relationship between steam pressure and temperature.

3.0 Case Study A – MTHW system at the Royal Derby Hospital

The Royal Derby Hospital covers some 158,000m² and employs an MTHW system with a flow and return temperature differential of 105°C – 90°C (Δt 15K) for the conveyance of heat energy around the Estate. The system uses a total of eight Hartley and Sugden SCP H 3500 kW MTHW dual fuel gas/oil boilers each fitted with a Dunphy TD3000 control panel and burner.

The system pressure for the main MTHW system within the boiler house is 4.0 bar(g) with the system pressures for the variable temperature heating circuits at 2.5 bar(g) and the constant temperature heating circuits at 2.0 bar(g).

All of the heat exchangers around the estate have a temperature differential of 75°C – 64°C (Δt 11K) on the secondary side, and all circuits have their own system pressurisation units.

Fig 1. MTHW primary circulation pumps and pressurisation units – The Royal Derby Hospital

3.1 MTHW boiler combustion efficiencies

Combustion reading MTHW boiler no.1 – The Royal Derby Hospital

Gas	CO2 (%)	O2 (%)	CO (%)	Efficiency (%)	Flue Temperature (Deg)
High Fire	9.5	4.2	0.0024	82.7	196.8
Low Fire	7.8	7.2	0.0022	85.7	113.3

Oil	CO2 (%)	O2 (%)	CO (%)	Efficiency (%)	Flue Temperature (Deg)
High Fire	12.6	3.9	0.0038	86.7	197.8
Low Fire	9.8	7.6	0.0027	88.2	140

The boiler appears to be more efficient when set up to burn oil rather than gas due to a higher gross calorific value for oil, with higher flue gas temperatures achieved. This could be advantageous for a steam boiler which utilises this energy to preheat the feed water. Manufacturer's data claims net efficiencies of this model of boiler to be 92.3%.

Fig 2. MTHW boiler – The Royal Derby Hospital

3.2 System advantages and disadvantages

- The heating system is a sealed system and therefore is not open to atmospheric pressure. This avoids losses associated with condensate pipe work for a steam system.

- The system requires only one dose with glycol to prevent corrosion (subject to there being no leaks within the system) unlike a steam system which requires constant chemical dosing.

- Annual boiler strip downs are less intensive as the only mechanical ancillary equipment needed to be inspected are the safety valves and so the turnaround was usually carried out within one working day.

- For steam systems it is necessary to achieve what is known as double block and bleed isolation before a steam system can be opened up or worked on. On MTHW system the temperature can be lowered to 80°C which then means that hot water is no longer a “relevant fluid” as described within the Pressure Systems Safety Regulations 2000, and so the system can be isolated using single valve isolation unlike a steam system, thus saving on overall downtime when insurance inspections are required to be carried out (HSE, 2000).

- The main disadvantage with the MTHW system was that the water requires a motive force (a pump) to transfer heat energy around the estate and that these pumps are associated with expensive maintenance.

- Maintenance engineers must pay attention to important health and safety issues when dealing with MTHW, in particular leaks can flash to steam at atmospheric pressure.

4.0 Case study B – Comparison of condensate recovery pump installations at Wythenshaw Hospital

The following represents a comparison of the performance of existing (reconditioned) mechanical condensate pumps at Wythenshaw Hospital against the alternative of replacing these with electrically driven pumps.

On any steam system, once the steam has given up its latent heat, the resulting condensate must be returned to the boiler via a hot well. The condensate is at saturation temperature (i.e. boiling) and it is critical to return it as quickly and directly as possible so that heat energy is not lost and maximum possible heat energy is extracted from the condensate. This task is performed by condensate return pumps, of which there are two types; namely mechanically driven steam cylinder pumps and electrically driven impellor type pumps.

The major comparative factors are listed below:

- There was no record of problems with cavitation. Cavitation can occur sometimes with electrically driven condensate pumps especially if steam traps happen to fail, which can elevate temperatures within the condensate line.

- Mechanical pumps were found to be virtually maintenance free. Should failure occur, repair is a relatively simple process with a standard overhaul kit. However, qualified authorised persons for boilers and pressure systems are required and an isolation permit must be prepared before work commences. Delays in this process can mean that condensate is wasted to drain with a consequent energy loss.

- Electrically driven condensate pumps were found to handle greater quantities of condensate and can operate in duty standby mode

- Electrically driven condensate pumps were found to require more maintenance with mechanical seals being changed when leaks have developed or motor bearings failing on occasions due to normal wear and tear.

- The operation between start and stop on electrical pumps was observed to take approximately twelve minutes in total, and this of course causes inefficiencies because the condensate has been allowed to cool.

- Electrically driven pumps suffered a lot with drive shaft seals or packing glands failing.

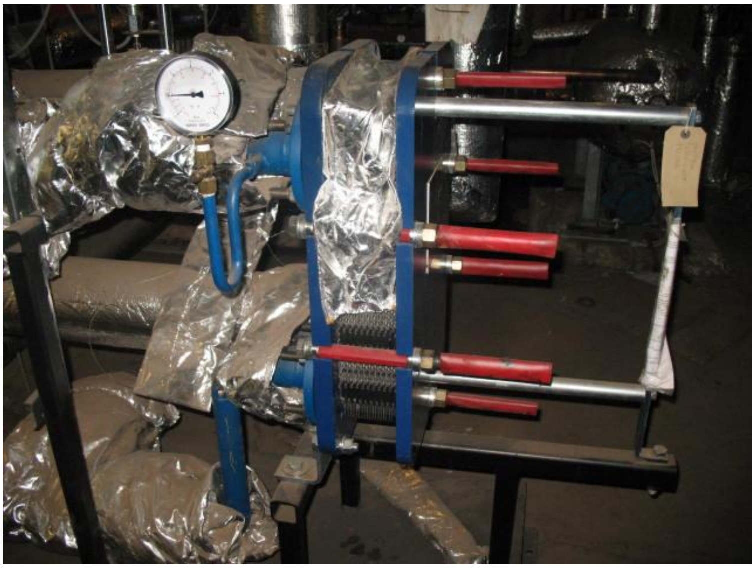
- Mechanical pumps create a more constant flow of condensate back to the hot well which reduced standing emission losses

This case study tends to infer that steam pumps will provide a better performance both in energy and operational maintenance terms.

5.0 Case study C – Replacement of steam calorifier with plate heat exchanger at Wythnenshaw Hospital

Whilst steam is an excellent medium for delivering energy for applications such as space heating, it is common practice to use the steam in a heat exchanger to generate low temperature hot water (LTHW) or for heating domestic hot water. This case study compares the performance of a plate heat exchanger with an existing storage calorifier.

Fig 3. Plate heat exchanger – University of Manchester Wythenshawe Hospital



The plate heat exchanger package was considered to have attained better overall control than the old shell and tube heat exchanger as it was more responsive to changes in the load conditions, and regularly achieved temperatures that were plus or minus 1°C of set-point.

Typically the old shell and tube unit would tend to cycle which meant that the set-point was constantly set higher in order to attain the required temperature at all times. This increased emissive heat loss. Major factors concerning heat exchangers are listed below:

- Plate heat exchangers can meet the same duty at a lower set point delivering large savings because the water flowing through the entire system is at a lower temperature which in turn reduces distribution losses and overheating.

- Better control of valves also meant less wear and tear with a lower carbon footprint and that savings of around 5% could be achieved as opposed to a shell and tube calorifier.

- Plate installations saved up to 15 working days of maintenance work each year with regard to strip downs for statutory insurance inspections.

- Plate heat exchangers minimize the need for hot water storage which eases the risk of legionella contamination

6.0 Comparing maintenance requirements of MTHW and steam systems

The maintenance of both types of system is compared by considering a typical maintenance application for the steam and hot water systems detailed in schematics included in Appendices A and B.

6.1 Maintenance of steam systems

Steam boilers are required to be shut down and prepared annually for an insurance inspection by a competent person (usually a qualified insurance inspector).

The steam boiler is isolated by the authorised person for boilers and pressure systems on site as part of the site safe system of work, which then allows a competent person to work on the steam boiler.

The preparation work needed for inspection by the competent person is as follows:

1. Removal of the safety valves
2. Removal of the gauge glasses
3. Removal of furnace concrete plugs
4. Removal of the waterside plugs
5. Removal of the level controls if purge sequencing valves are used (not part of this design – level controls are high integrity self-monitoring)
6. Removal of boiler feed water valves
7. Removal of the blow down valve

8. Removal of the front and rear furnace end plates to enable inspection of the furnace tubes.

All of the work above would be estimated to require 48 man-hours and a similar period would be needed to reinstate the steam boiler back to full service again, at which point a final working inspection is carried out by an insurance inspector.

Every five years an NDT insurance inspection is required to be carried out which involves all of the above plus a specially trained insurance inspector who checks for steam boiler shell thickness at various parts of the boiler. The NDT inspection also requires the removal of the refractory around the burner on the inside of the furnace which is usually carried out by specialist sub-contractors.

Quarterly combustion tests are carried out together with flue gas analysis by suitably qualified industrial gas safe engineers as part of a service to the boiler burner and readings are submitted to the maintenance staff together with a CP15 gas safety certificate issued on an annual basis.

Moving on from the steam boiler, the next plant item to be considered is the pressure reducing stations which are virtually maintenance free; however they do suffer from wear and tear and require overhaul on average every 10 years. This involves the safe isolation of the plant and removal, strip down and replacement of the pressure reducing set components by a suitably qualified fitter.

The next item of plant shown on the schematic is the domestic hot water plate heat exchanger will requires only a visual insurance inspection which is carried out on an annual basis. Unlike the domestic hot water plate heat exchanger, the steam heating calorifier does require a full isolation and strip down for the insurance inspector to carry out a thorough inspection of the calorifier internal tubes together with the tube plate. Once the insurance inspector has verified that all is in good order the plant is then assembled and put back into service and a working inspection is then carried out.

Overall from isolation to strip down and reassembly the inspection can be turned around within one week using two fitters.

The final plant item which requires maintenance on the steam system is the steam trap associated with the domestic hot water plate heat exchanger and the heating calorifier. With the steam trap a performance meter is plugged into a bespoke port on the steam trap and this will indicate that it is working satisfactorily as per specification. This is usually carried out on an annual basis and should the steam trap fail, then it is replaced as necessary.

6.2 Maintenance of MTHW systems

Quarterly combustion tests are carried out together with flue gas analysis by suitably qualified industrial gas safe engineers as part of a service to the boiler burner and readings are submitted to the maintenance staff together with a CP15 gas safety certificate issued on an annual basis.

An annual insurance inspection is carried out to the medium temperature hot water boiler by a competent person which requires the same level of isolation and strip down as the steam boiler. Again every 5 years there is a requirement for an NDT insurance inspection by a suitably qualified insurance inspector which is usually carried out at the same time as the thorough inspection carried out on the annual.

The noticeable difference with the MTHW system is that there are system pressure vessels which are visually inspected annually, together with an NDT inspection carried out by using a special device which measures the thickness of the vessel. Also, within the MTHW system are main inverter driven circulating pumps, and these require an annual service to ensure that they are working within set parameters. On occasion the mechanical seals and drive motor bearings do fail which invariably require the pump to be removed and sent away for overhaul. Repairs for heating pumps of this size can be quite a costly exercise.

Moving further on down the heating system there are exactly the same annual insurance inspections carried out to the domestic hot water plate heat exchangers and heating calorifiers as experienced on the steam system apart from the lack of steam traps.

7.0 Comparing sustainability aspects and life-cycle costs

7.1 Steam heating system

Within the boiler house at the Wythenshawe Hospital there is a duty and standby shell and tube Byworth model YSX steam boiler is capable of delivering 11250 kg/hr of steam at 7 bar pressure which runs on natural gas with manufacturer's claim of 96% net efficiency.

Steam boiler ratings are normally stated as boiler output in kg/hr steam “from and at” 100°C at atmospheric pressure, which means that that when the boiler is fed with water at 100ºC and steam is produced at 100ºC then the boiler will produce the stated kilograms of steam per hour which in this case is 11250 kg/hr. In practice steam boilers are operated at higher pressures, which mean that more heat energy will be required than if it were to operate at 100ºC and at atmospheric pressure.

Fig. 4 Byworth steam boiler – University of Manchester Wythenshawe Hospital

Energy losses occur through the steam boiler stack (typically 17%), radiation from the boiler shell (1%), and boiler blow down (2%). Blow down refers to the process of releasing steam from a valve underneath the boiler by which some of the dissolved solids contained in the boiler water are discarded to waste. This action reduces the total of scale forming salts within the boiler water and reduces scale build-up on the water side of the boiler (Spirax Sarco Ltd., 2012).

Boiler efficiency can be increased by the addition of an “economiser”, this being effectively an additional heat exchanger placed within the steam boiler flue making use of the latent heat contained within the flue gases. The economiser is installed between the high pressure discharge side of the feed water pump and the steam boiler and can increase boiler efficiencies up to 4%.

Flash Steam Recovery

The condensate which is generated from the process at the heat exchanger enters the steam trap as saturated water and at a gauge pressure of 4.0 bar and a temperature of 151.96 °C with 640.7 kJ/kg of heat.

At this temperature and pressure this water would immediately turn to steam if exposed to atmospheric pressure. A flash-steam recovery vessel exploits this fact by allowing the condensate into a vessel at a lower pressure so that some of the condensate will “flash off” into steam. This lower pressure steam can be used to provide some heating application and the resulting condensate is then returned to the hot well.

Swagelock Energy Advisors (2011) confirm that one of the best economic returns on steam systems may be realised by returning condensate back to the steam boilers, rather than discarding it. They advise that condensate may contain as much as 16% of the total energy in the steam vapour, depending on system working pressures (Swagelock Energy Advisers, 2011).

The carbon footprint attached to such a heating system based on the same heating load has been calculated using the carbon footprint calculator given on the Carbon Trust website (Carbon Trust, 2012a). This calculation shows that the steam system generates a total of 1994.95 tonnes of CO_2 per annum.

The life cycle costs for the steam system shown in Table 1 below, have been calculated using the discounted net present value method (Beggs, 2009) using a normal labour charge rate of £26.23p per hour on the following data:

- Annual cost for gas: - £288009.18p (4% annual rise)
- Annual cost for water: - £14786.88p (4% annual rise)
- Annual cost for electricity: - £3237.55p (5% annual rise)
- Annual maintenance cost: - £2938.40 (4% annual rise)
- NDT Insurance inspection: - £1200.00 (Every 5 Years)
- The real rate of interest @ 4.5%
- The retail price index @ 5%
- System lifespan of 20 Years

According to Churcher (2008), “life cycle costing incorporates many assumptions and estimates. Ideally these estimates should be precise but that is not always possible”. The results of this life cycle calculation provide an interesting comparison; however it may differ if the sensitivity of some of the assumptions were subject to a deeper analysis.

The replacement of damaged pipe work insulation is also critical to the steam heating system in order to reduce heat radiation energy loss. Swagelock also state that best practice for condensate is for all devices within the condensate system to be insulated to prevent thermal energy losses (Swagelock Energy Advisers, 2011).

It was also considered that if condensate was not returned to the steam boiler then the system has to make-up the system water loss, and this not only contributes to system energy loss and water treatment losses, but also additional energy is required to bring the make-up water up to operating temperature (Swagelock Energy Advisers, 2011).

The Carbon Trust (2012b) in publication CTV052, also advises that additional energy savings to steam boiler plant may be made of up to as much as 20% by use of various techniques and methods, such as regular maintenance (5%) or the installation of an economiser within the flue system (5%) and the control of steam boiler blow down with use of flash steam recovery (2%) (Carbon Trust, 2012b).

Table 1 Life cycle costs – steam system

LIFE CYCLE COST - STEAM SYSTEM

Client: Wythenshawe Hospital

Prepared By: Kenneth Eaton

Year	Capital Cost	Maintenance Cost	Water Cost	Gas Fuel Cost	Electric Fuel Cost	Overhaul	Net Cost	Discount factor	Present Value Cost
0.00	278316.04						278316.04	1.00	278316.04
1.00		2938.40	14786.88	288556.68	3237.55	2938.40	312457.91	0.91	284764.56
2.00		3055.94	15378.36	300098.95	3399.43	2938.40	324871.07	0.83	269835.98
3.00		3178.17	15993.49	312102.91	3569.40	2938.40	337782.37	0.76	255693.80
4.00		3305.30	16633.23	324587.02	3747.87	2938.40	351211.82	0.69	242296.29
5.00		3437.51	17298.56	337570.50	3935.26	4138.40	366380.23	0.63	230358.42
6.00		3575.01	17990.50	351073.32	4132.03	2938.40	379709.26	0.57	217579.34
7.00		3718.01	18710.12	365116.26	4338.63	2938.40	394821.42	0.52	206187.14
8.00		3866.73	19458.53	379720.91	4555.56	2938.40	410540.12	0.48	195393.85
9.00		4021.40	20236.87	394909.74	4783.34	2938.40	426889.75	0.43	185167.78
10.00		4182.26	21046.34	410706.13	5022.50	4138.40	445095.63	0.40	175953.31
11.00		4349.55	21888.19	427134.38	5273.63	2938.40	461584.15	0.36	166298.91
12.00		4523.53	22763.72	444219.75	5537.31	2938.40	479982.71	0.33	157600.84
13.00		4704.47	23674.27	461988.54	5814.17	2938.40	499119.86	0.30	149359.27
14.00		4892.65	24621.24	480468.08	6104.88	2938.40	519025.26	0.27	141550.12
15.00		5088.36	25606.09	499686.81	6410.13	4138.40	540929.78	0.25	134448.84
16.00		5291.89	26630.34	519674.28	6730.63	2938.40	561265.54	0.23	127139.05
17.00		5503.57	27695.55	540461.25	7067.17	2938.40	583665.93	0.21	120495.08
18.00		5723.71	28803.37	562079.70	7420.52	2938.40	606965.71	0.19	114199.33
19.00		5952.66	29955.51	584562.89	7791.55	2938.40	631201.00	0.17	108233.44
20.00		6190.77	31153.73	607945.40	8181.13	4138.40	657609.42	0.16	102767.61
								Total Life cycle Cost	£3,863,638.99

7.2 Medium temperature hot water system

For the MTHW system, within the boiler house at Wythenshawe Hospital there is a duty and standby Byworth Dalesman gas boiler which is capable of delivering 7MW of heat output, and with a manufacturer's claim of up to 91% efficiency with the installation of an economiser in the flue.

Fig 5. Byworth MTHW boiler – University of Manchester Wythenshawe Hospital

The Carbon Trust (2012b) reports an example of an economiser heat recovery device and advanced controls were fitted to a MTHW boiler at an international food processing company. It was shown that there were annual cost savings of £55,000.00, with energy savings of about 7000MWh which equated to CO_2 savings of around 1300 tonnes and a 9.8% increase in boiler efficiency with a payback period of one year (Carbon Trust, 2012b).

For the purpose of this paper similar boiler efficiencies have been assumed and an efficiency calculation has not been carried out, however for the MTHW system it must be pointed out that there is no available flash steam or condensate recovery available.

The carbon footprint calculation, carried out in the same way as for the steam system, shows that the MTHW system generates a total of 2061.82 tonnes of CO_2 per annum.

The life-cycle costs have been calculated in the same way as for the MTHW system using the discounted net present value method (Beggs, 2009) using a normal labour charge rate of £26.23p per hour on the following data:

- Annual cost for gas: - £288009.18p (4% annual rise)
- Annual cost for electricity: - £14275.15p (5% annual rise)
- Annual maintenance cost: - £2938.40 (4% annual rise)
- NDT Insurance inspection: - £1200.00 (Every 5 Years)
- Replacement of expansion vessels: - £3000.00 (Every 15 Years)
- The real rate of interest @ 4.5%
- The retail price index @ 5%
- System lifespan of 20 Years

Table 2 Life cycle costs – MTHW system

LIFE CYCLE COST - MEDIUM TEMPERATURE HOT WATER SYSTEM								
Client: Wythenshawe Hospital								
								Prepared By: Kenneth Eaton
Year	Capital Cost	Maintenance Cost	Gas Fuel Cost	Electric Fuel Cost	Overhaul	Net Cost	Discount factor	Present Value Cost
0.00	190656.76					190656.76	1.00	190657.76
1.00		2938.40	288009.18	14275.15	2938.40	308161.13	0.91	280848.60
2.00		3055.94	299529.55	14988.91	2938.40	320512.79	0.83	266216.02
3.00		3178.17	311510.73	15738.35	2938.40	333365.66	0.76	252350.45
4.00		3305.30	323971.16	16525.27	2938.40	346740.13	0.69	239211.33
5.00		3437.51	336930.00	17351.53	4138.40	361857.45	0.63	227514.76
6.00		3575.01	350407.20	18219.11	2938.40	375139.73	0.57	214960.93
7.00		3718.01	364423.49	19130.07	2938.40	390209.97	0.52	203778.91
8.00		3866.73	379000.43	20086.57	2938.40	405892.14	0.48	193181.67
9.00		4021.40	394160.45	21090.90	2938.40	422211.15	0.43	183138.39
10.00		4182.26	409926.87	22145.44	4138.40	440392.97	0.40	174094.27
11.00		4349.55	426323.94	23252.72	2938.40	456864.61	0.36	164598.56
12.00		4523.53	443376.90	24415.35	2938.40	475254.18	0.33	156048.24
13.00		4704.47	461111.98	25636.12	2938.40	494390.97	0.30	147944.17
14.00		4892.65	479556.46	26917.92	2938.40	514305.43	0.27	140262.91
15.00		5088.36	498738.71	28263.82	7138.40	539229.29	0.25	134026.18
16.00		5291.89	518688.26	29677.01	2938.40	556595.57	0.23	126081.19
17.00		5503.57	539435.79	31160.86	2938.40	579038.62	0.21	119539.80
18.00		5723.71	561013.22	32718.91	2938.40	602394.24	0.19	113339.21
19.00		5952.66	583453.75	34354.85	2938.40	626699.66	0.17	107461.59
20.00		6190.77	606791.90	36072.59	4138.40	653193.66	0.16	102077.53
							Total Life cycle Cost	£3,737,332.49

8.0 Comparing heat losses and energy use

In a comparison of system operating energy use for steam against MTHW, the two major factors are pipework heat emission losses and the power required for pumping. Because steam has a higher heat capacity than MTHW, pipe sizes may consequently be smaller than those for MTHW systems, and this would therefore be expected to reduce emission losses. However, since temperatures in steam systems tend to be higher than in MTHW systems, the difference between the temperatures of pipework and their surroundings may also be greater, and the savings due to smaller pipes may not be quite as sizeable as might be expected.

In steam systems the pressure generated within the boiler provides much of power to convey the steam through pipe systems, and it may be expected therefore that this constitutes a considerable energy saving over MTHW systems. However, condensate return is often pumped using steam or electrically driven pumps, both of which of course consume energy. It can be shown though, that if steam generated by a local boiler is used to drive condensate return pumps, this represents a lower use of primary energy than electrical condensate pumps drawing electricity from the national grid. This point could constitute part of a valid argument in favour of a combined heat and power installation.

9.0 Specialist hospital processes

Steam for heating is often a by-product from some industrial process. Steam in the Health Service is used for sterilization, cooking and, in some cases for laundries. Clearly this enhances the case for steam heating where these applications are required.

Sterilization using steam in autoclaves is made more straightforward because, providing the autoclave can create a vacuum condition, the steam saturation temperature is conveniently controlled in relation to its pressure. However, sterilizing with steam does not necessarily mean that this steam must be generated from a plant which serves the whole site.

10.0 Further discussions

The case studies would appear to indicate that although a steam heating system is often thought of as an inefficient way of heating a building it can in fact be a relatively efficient way of heating an NHS building providing that it is well maintained.

With modern day fuel efficient steam boilers come higher efficiencies and by installing modern controls together with efficient ways of harnessing what was seen as waste heat by way of heat recovery, the system can be made more efficient.

Capital costs appear largely to favour MTHW heating systems due to the initial outlay for plant items, however these must be offset against the costs of larger pipe work and some ancillaries.

A further commentary relevant to this discussion, presented by Wade (1995), is provided by the replacement of a steam system with a pressurised hot water system at the Savannah Regional Hospital, a large scale complex in the USA. This contract was completed in 1994, and although nearly 20 years old, complete projects of this nature are few and far between.

The president of the contracting company presented a paper to the annual conference of the District Energy Association, claiming 58% savings when comparing the new pressurised hot water system against the steam system it replaced (Wade, 1995).

A cynical observer might consider that it is only to be expected that the company president would present a certain point of view. The paper is brief and short on technical detail but it does appear that, although the hot water system does clearly demonstrate energy benefits, it is not clear how much of the savings were due directly to the change in heating medium, and how much was achieved by better maintenance, operation and control. The report does allude to frequent steam leaks and flooding in the original system, and it could well be argued that any replacement would improve substantially on this, whether MTHW or steam.

10.1 Advantages and disadvantages of steam systems

This paper has identified that both new and existing steam systems can be made more efficient and cost effective. The recovery of as much flash steam and condensate as possible and the use of steam driven rather than electrically driven condensate recovery pumps would contribute to this, as would the use of steam plate heat exchangers rather than steam calorifiers.

A draft design carried out (appended) for both systems highlights that installation and maintenance costs may be reduced for steam systems due to smaller pipe work over longer distances, no requirement for system pumps and balancing valves, and this can make them compare favourably to MTHW systems.

Maintenance on steam systems is less than for MTHW systems, as these require fewer electrical plant items (particularly large pumps) that require attention, though both systems require insurance inspections at the same intervals.

The installation of an economiser together with flash steam recovery was also identified as being a good way of making the steam driven plant more energy efficient.

Temperatures and in turn pressures are easily controllable in a steam system by way of pressure reducing valves and two port control valves rather than three port valves on the MTHW system.

The pipe work system shown on each schematic (see Appendix) highlights steam's flexibility when new or additional plant is required to be installed.

The main disadvantage with a steam system would tend to be life-cycle costs, since there is a constant need for top up water and this requires expensive treatment, however there could be considerable conjecture about this since the quantity of condensate return is very much an unknown quantity unless leaks are identified and feed water use is properly metered. In addition steam requires a permit initiating under a safe system of work in preparation for statutory insurance inspections which can delay important operations that need to be carried out to maintain compliance.

10.2 Advantages and disadvantages of MTHW system advantages

MTHW system pressure and temperature can be reduced fairly easily for certain parts of systems, meaning that these sections do not carry a relevant fluid that requires periodic insurance inspections. Fewer insurance inspections can be considered to be a considerable advantage.

It can also be shown that life-cycle costs for the MTHW system are lower than steam systems due to MTHW systems requiring less top up water and water treatment.

MTHW heating systems do not contain as high a quantity of heat as steam systems and this means that the steam system pipework may often be smaller. This is demonstrated in the design case study for Wythenshawe Hospital.

It was also noted within case study B that MTHW depends on large circulating pumps to overcome the resistance of the pipe work distribution system, where there are none on a steam heating system, although the condensate return pumps perform a similar function, and additionally existing steam supplies maybe utilised to push condensate back to the hot well for reuse by mechanical pumps. This process still requires energy, though less primary energy than if all fluid is moved by electrically driven pumps.

The case study carried out for the Royal Derby Hospital highlighted that although MTHW was easier to work with when insurance inspections were carried out, there have been incidents in which hot water has flashed to steam because leaking pipework. This can create danger and is a potential health and safety issue. and safety issue.

A Victorian Hangover?

So, is steam a modern heating medium? The short answer is yes, steam is a modern heating medium. However, short answers do not always provide the level of detail needed by engineers.

A slightly longer answer is that steam should not automatically be discounted as a Victorian technology. Steam has an important role in modern building engineering systems. But, like many questions in engineering the answers are not simply either/or. This study has shown that steam and high temperature hot water can be competitive energy-wise and financially. However, what comes across strongly from this research is that system performance is related to good design and, perhaps a less glamorous area: operation and maintenance. The skills and knowledge needed for the operational phase can contribute to the design phase of a project.

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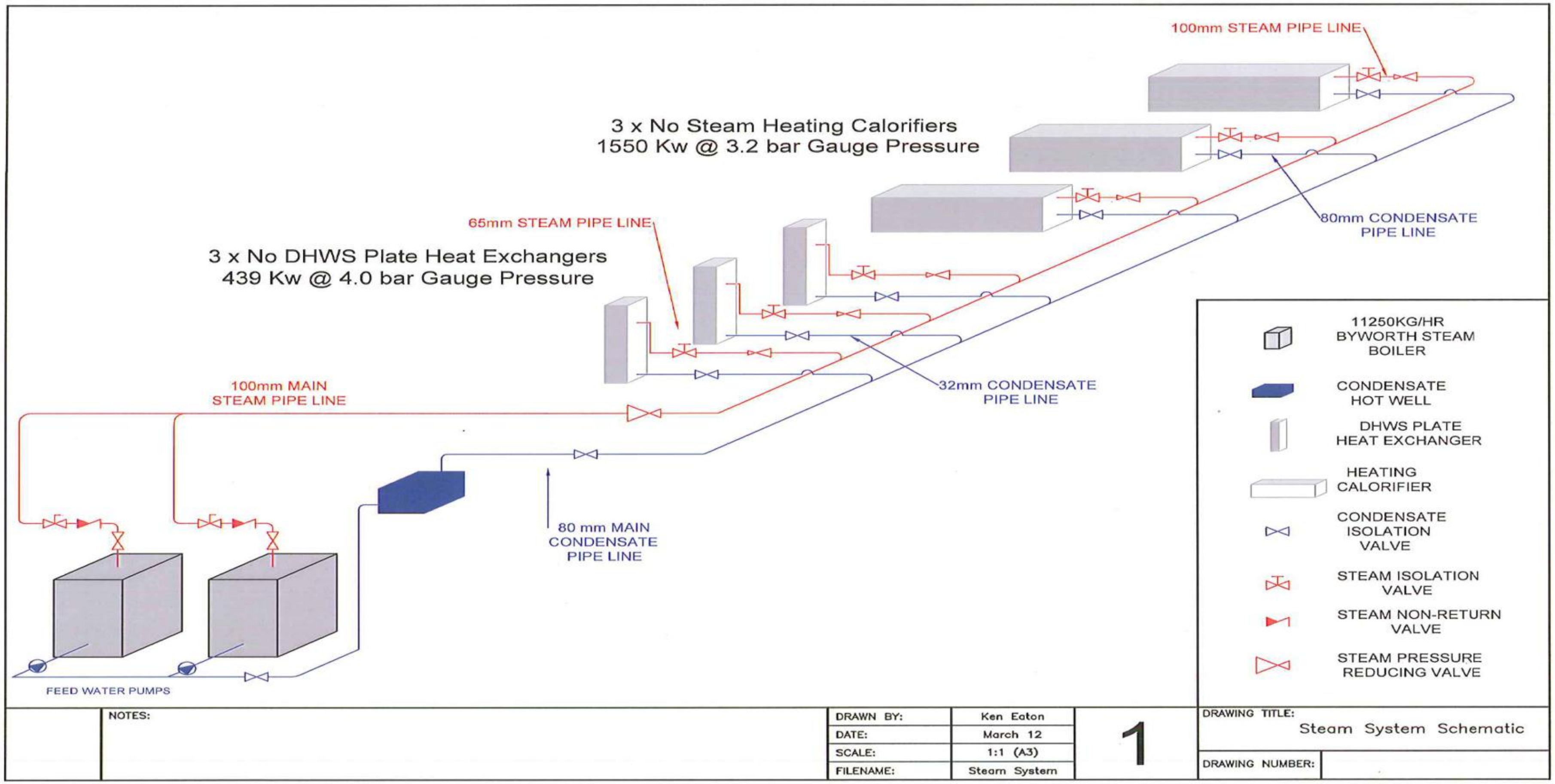
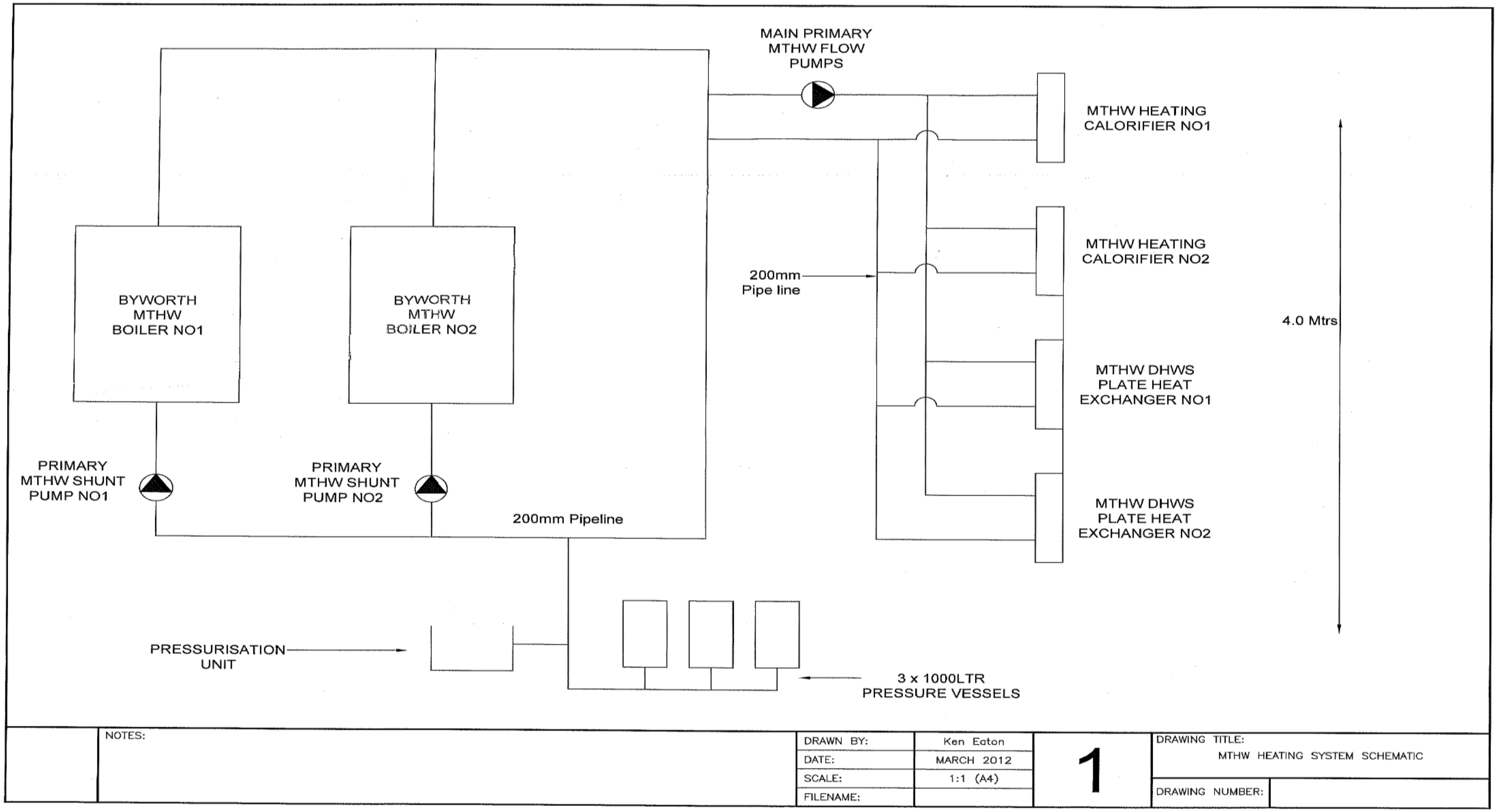
Appendix – Draft designs comparing steam and MTHW installations




MAIN PRIMARY MTHW FLOW PUMPS
MTHW HEATING CALORIFIER NO1
MTHW HEATING CALORIFIER NO2
MTHW DHWS PLATE HEAT EXCHANGER NO1
MTHW DHWS PLATE HEAT EXCHANGER NO2
200mm Pipe line
4.0 Mtrs
BYWORTH MTHW BOILER NO1
BYWORTH MTHW BOILER NO2
PRIMARY MTHW SHUNT PUMP NO1
PRIMARY MTHW SHUNT PUMP NO2
200mm Pipeline
PRESSURISATION UNIT
3 x 1000LTR PRESSURE VESSELS
NOTES:
DRAWN BY: Ken Eaton
DATE: MARCH 2012
SCALE: 1:1 (A4)
FILENAME:
1
DRAWING TITLE: MTHW HEATING SYSTEM SCHEMATIC
DRAWING NUMBER: