Section 1 - Energy Use at Whitchurch Hospital

Figure 1 - Ground view of the ornate water tower below with boiler house, pump room and power house (Fussell, 2019)

At the time of its inception in the early 1900's Whitchurch was on frontier of Edwardian technological advancements in building technology services. In its design phase the implementation of a clean sterile environment was of highest priority, as the ventilation system, plumbing and drainage system are visible in the architectural drawings. Its ability to remain self-sufficient on the edge of Cardiff's expanding borders was typical of mental institutions, and the falling price of installations of new technology enabled them to provide water and heat to its patients and staff through cleaner energy. The hospital itself would have contained a number of facilities such as; farm buildings, kitchen, laundry fire station, staff cottages, mess rooms and operation rooms and more. This section will cover the energy services that would have been essential to its daily functions, from its opening in 1908 through to its use as a wartime hospital. Further analysis will be undertaken of the effectiveness of its fabric and to highlight requirements needed to aid proposals for its future alternative use.

The layout of Whitchurch hospital represents the culmination of the 19th Century Nightingale 'pavilion', with an overall block layout and architectural style developed from the changing mix of social, sanitary and medical needs of Victorian society. It was essential that the hospital retained its cleanliness, including air supplied to the wards. Florence Nightingale's 'Notes on Hospitals' and campaigns published in 1850 from 'The Builder' magazine set out ideas for approved hospital and asylum architectural designs (Taylor, 1991, p17). By improving these conditions infection and mortality rates decreased, highlighting the danger of cross contaminated air.

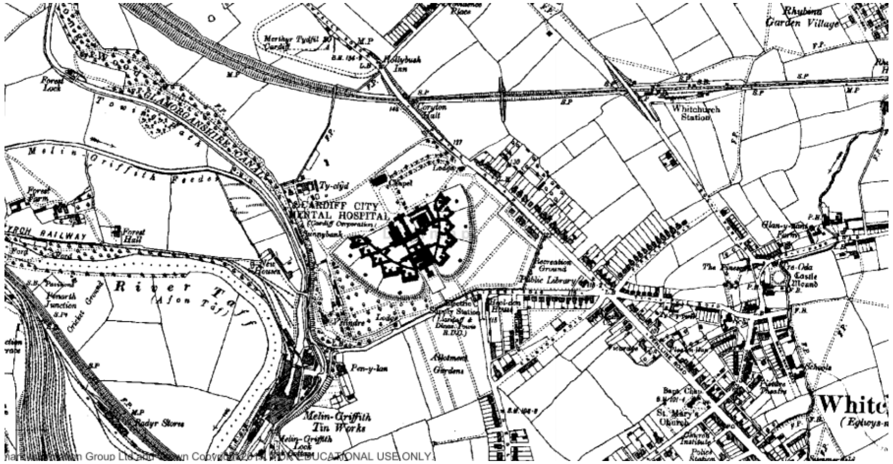


Figure 2 - Ordinance survey image of Whitchurch and the hospital in 1920

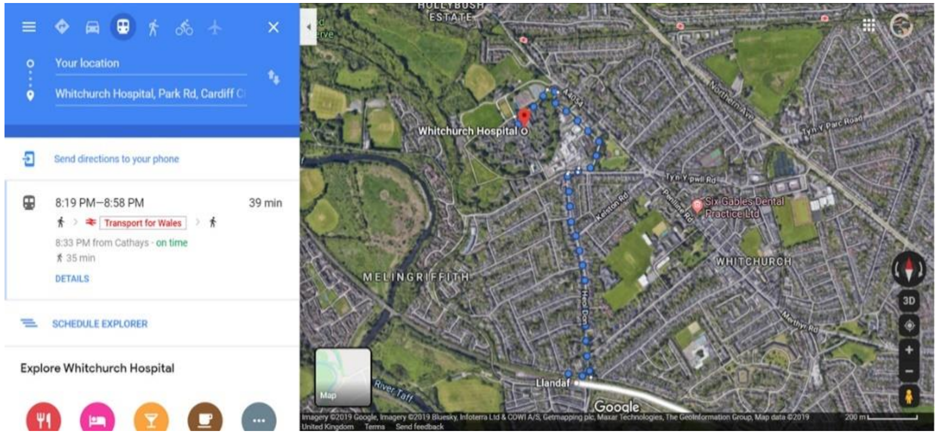


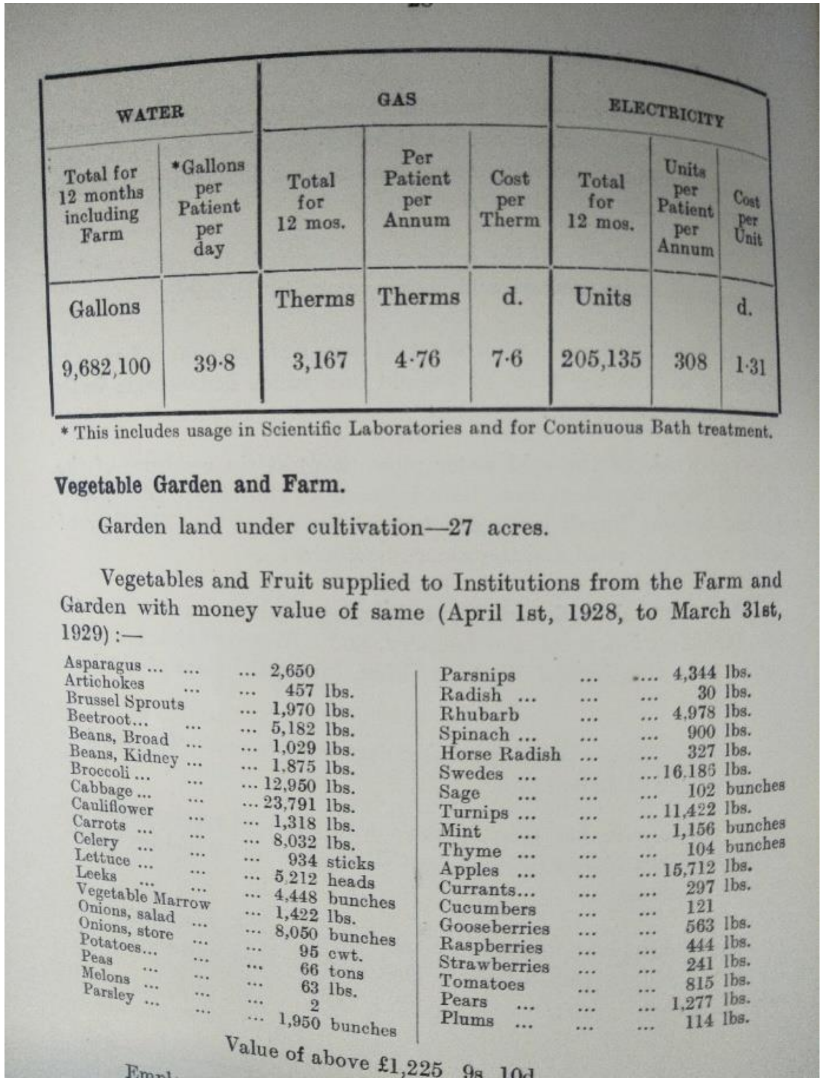
Figure 3 – Google satellite image of the hospital, showing current route by road from Cardiff and surrounding train stations

Transport

The site was designed to be within a moderate distance of Cardiff town centre, beneficial for the transportation of patients, and the procurement of essential supplies such as food, medicines and coal. Services within the hospital aimed to be self-sufficient, with trade workshops and land for agriculture, producing fruit, vegetables and livestock (Thomas 1983, p11). As figure 2 and 3 show the hospital was and still is within close proximity to rail and road links and in 1920 the Glamorgan canal. In both aerial images of the hospital

Whitchurch to the north east and Llandaff to the south were in close proximity. Minutes show that the War Office in 1915 suggested the disembarking of patients from Whitchurch train station to the hospital, additional plans for a railway 'siding' closer to the hospital were discussed but never came into fruition (City of Cardiff, 1915, p25). In 1938 the city council minutes also show that coal was transported to the Melin-Griffith tin works and delivered across the canal due to the Hospitals large store of coal (City of Cardiff, 1938, p334).

Within Cardiff city centre itself, electrical cable-cars were a typical mode of transportation, records show that Buses (also called 'omnibuses') were in place to enable people to travel to and from the hospital, operated by the Tramways Company Limited. From the 1920's onwards a motorcar was in use by the Medical Superintendent Dr Goodall (City of Cardiff, 1915, p114) who had written to the council for the lighting and repair of roads leading to the hospital (City of Cardiff, 1908, p151). During wartime convoys of ambulances were driven to the site, during its use as one of the largest medical emergency services centres in the UK (City of Cardiff, 1948, 445).



WATER		GAS			ELECTRICITY		
Total for 12 months including Farm	*Gallons per Patient per day	Total for 12 mos.	Per Patient per Annum	Cost per Therm	Total for 12 mos.	Units per Patient per Annum	Cost per Unit
Gallons		Therms	Therms	d.	Units		d.
9,682,100	39·8	3,167	4·76	7·6	205,135	308	1·31

* This includes usage in Scientific Laboratories and for Continuous Bath treatment.

Vegetable Garden and Farm.

Garden land under cultivation—27 acres.

Vegetables and Fruit supplied to Institutions from the Farm and Garden with money value of same (April 1st, 1928, to March 31st, 1929) :—

Asparagus	2,650
Artichokes	457 lbs.
Brussel Sprouts	1,970 lbs.
Beetroot	5,182 lbs.
Beans, Broad	1,029 lbs.
Beans, Kidney	1.875 lbs.
Broccoli	12,950 lbs.
Cabbage	23,791 lbs.
Cauliflower	1,318 lbs.
Carrots	8,032 lbs.
Celery	934 sticks
Lettuce	5,212 heads
Leeks	4,448 bunches
Vegetable Marrow	1,422 lbs.
Onions, salad	8,050 bunches
Onions, store	95 cwt.
Potatoes	66 tons
Peas	63 lbs.
Melons	2
Parsley	1,950 bunches
Parsnips	4,344 lbs.
Radish	30 lbs.
Rhubarb	4,978 lbs.
Spinach	900 lbs.
Horse Radish	327 lbs.
Swedes	16.185 lbs.
Sage	102 bunches
Turnips	11,422 lbs.
Mint	1,156 bunches
Thyme	104 bunches
Apples	15,712 lbs.
Currants	297 lbs.
Cucumbers	121
Gooseberries	563 lbs.
Raspberries	444 lbs.
Strawberries	241 lbs.
Tomatoes	815 lbs.
Pears	1,277 lbs.
Plums	114 lbs.

Value of above £1,225 9s. 10d.

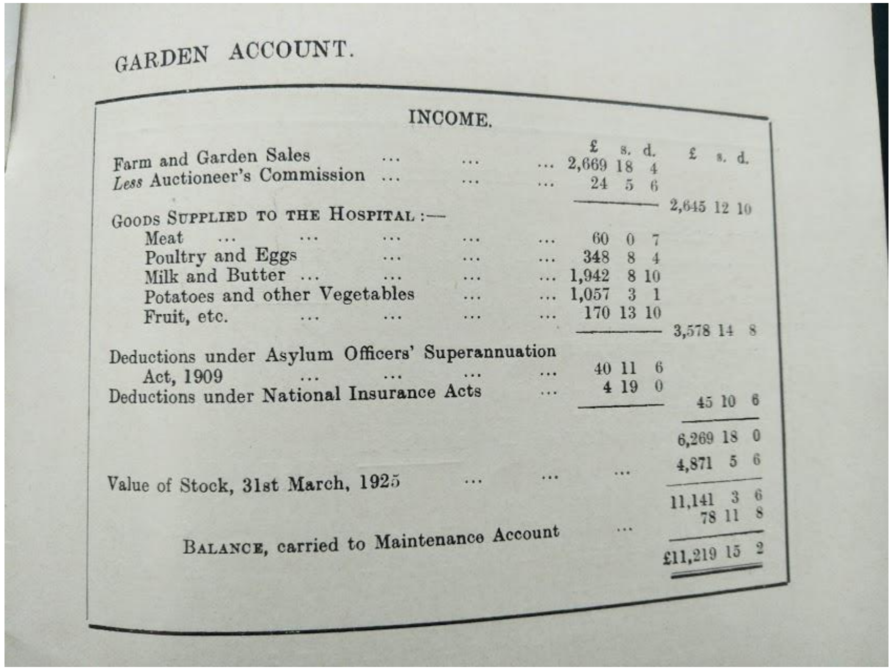
Figure 4 - Annual report summaries of energy use and farm yield (City of Cardiff, 1929, p28)

Farming

With its 27 acres the hospital had a plethora of farming abilities, moreover as the county minutes show, additional contracts were made for the procurement of tea, meat and vegetables (City of Cardiff, 1908, p355). The semi-autonomous agricultural unit was utilised for occupational therapy to patients providing more of an individualised treatment with a low patient to staff ratio (Loue, 2016, p2). Produce was used to feed patients, but also for sale in the local markets, the self-contained asylum included farm buildings, a large greenhouse and orchard.

In 1927 a review by commissioners of the board reported on the ‘improved’ diet of patients ‘boiled fish and potatoes with currant pudding – and porridge, kippers, corner beef, eggs are given 5 days a week. Each patient also has 1 eighth pint of fresh milk twice (City of Cardiff, 1927, p741). The tables show in figure 4 and 5 that the growing of vegetables was sustainable and profitable.

Shown in relation to the pie chart in Figure 6 showcasing the breakdown of the NHS England carbon footprint shows that procurement of goods and services was the most polluting element resulting in the most energy- consuming element of hospitals. In relation to the institution at Whitchurch the ability to grow their own food could eliminate the requirement for large supplies to be delivered and helped reassure council members of the expenditure required for the upkeep of patients.



GARDEN ACCOUNT.

INCOME.

	£ s. d.	£ s. d.
Farm and Garden Sales	2,669 18 4	
Less Auctioneer's Commission	24 5 6	
		2,645 12 10
GOODS SUPPLIED TO THE HOSPITAL :—		
Meat	60 0 7	
Poultry and Eggs	348 8 4	
Milk and Butter	1,942 8 10	
Potatoes and other Vegetables	1,057 3 1	
Fruit, etc.	170 13 10	
		3,578 14 8
Deductions under Asylum Officers' Superannuation Act, 1909	40 11 6	
Deductions under National Insurance Acts ...	4 19 0	
		45 10 6
		6,269 18 0
Value of Stock, 31st March, 1925		4,871 5 6
		11,141 3 6
		78 11 8
BALANCE, carried to Maintenance Account ...		£11,219 15 2

Figure 5 - Garden expenditure table (City of Cardiff, 1925, p25)

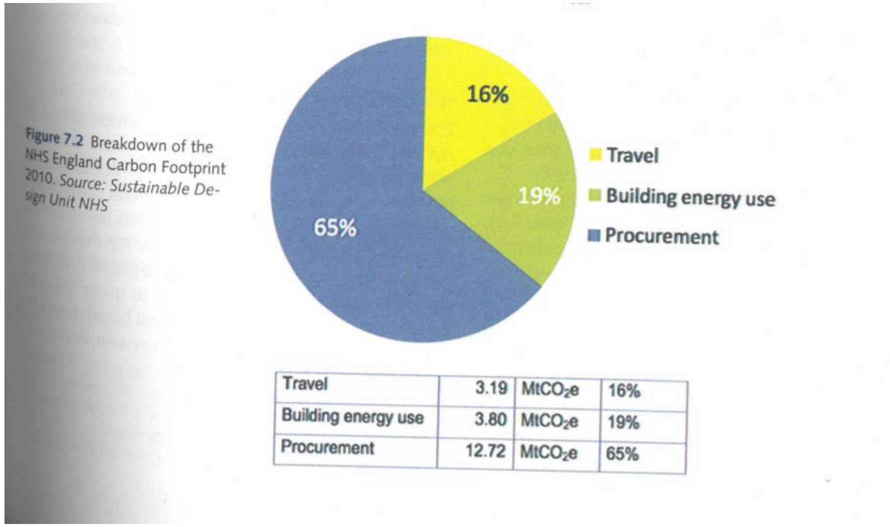


Figure 6 - Breakdown of the NHS England Carbon Footprint (Guenther, 2013, Pxvii)

Lighting and Design

A statement by Deputy Director of Medical Services in 1920 states that the hospital was the 'facile princeps of all the Mental War Hospitals…The structure is nearly new (1920) and thoroughly up-to-date plan. The equipment scientifically complete…All the wards have Verandas facing the South for open air-treatment' in a letter to the Director-General Army Medical Service printed in the minutes (City of Cardiff, 1920, p103). The pavilion design when used for wards in a sanity code means 'open ward' ventilated on both long sides by windows and on both short sides doors connected to a corridor that serves similar pavilions but self-contained with its own service rooms (Thompson 1976, p118).

Ventilation was of primary concern, but other details were highlighted with additional services such as the design of sanitation and drainage systems. One of the most important innovations to revolutionise hospital architecture was the discovery that bacteria are the main agents spreading disease through the air, the concentration of bacteria would be higher where the air was worst (Wagenaar, 2006, p31). These developments of detailed design and planning criteria for health buildings helped such institutions to re-brand themselves with names implying a place of refuge and rehabilitation (Thomas, 1991, p15). All pathways rooms and corridors within the hospital have large sash windows, which would allow with its orientation to make the most of daylight available but also ties into new ideal of light and airy spaces to eradicate disease.

Figure 7 - Interior of the corridor with roof lighting (Fussell, 2019)

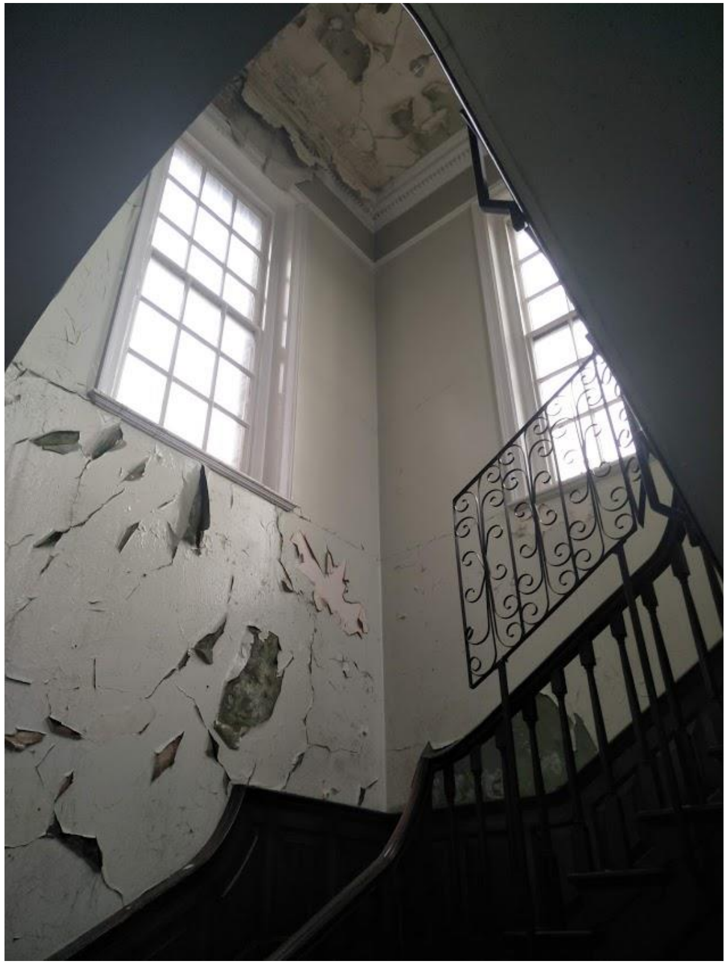


Figure 8 - Inside stairwell large sash windows providing natural lighting (Fussell, 2019)

Certain public buildings and large houses had been lit by experimental installations using locally generated electricity from the early 1880’s, most electricity supplies were run by local authorities from an early date until nationalisation of the industry in 1948 (Johnson, 2006, p155).

The introduction of incandescent lamps or ‘glow lamps’ in 1880 and their gradual reduction in costs meant that electric light was a feasible alternative to gas of which was a safety hazard, created heat and blackened furnishings (Fellows, 1999, p116). Private companies at first at set up power stations and by 1889 publicly generated supplies were available for civic and private buildings.

In 1908 the city council minutes show the Cardiff Gas Light and Coke Company provided a quote for the laying of service pipes for the supply of gas to 300 candle power lamps ion the grounds for the sum of £90 (City of Cardiff, 1908, p20). The Medical Superintendent Dr Goodall then reported the advantages of electrical lighting which would have been substantially cheaper and cleaner, resulting in a running cost of £20 per annum. Further to this the records also indicate the installation of Electric bells at Entrance lodge and gate (City Council, 1908, 20). In figure 9 an image believed to be dated around the 1920’s shows the layout of one of the wards with three light electroliers hanging from the ceiling rather than a gas ceiling pendant, the light switches on the walls suggests that this would be electrical lighting.

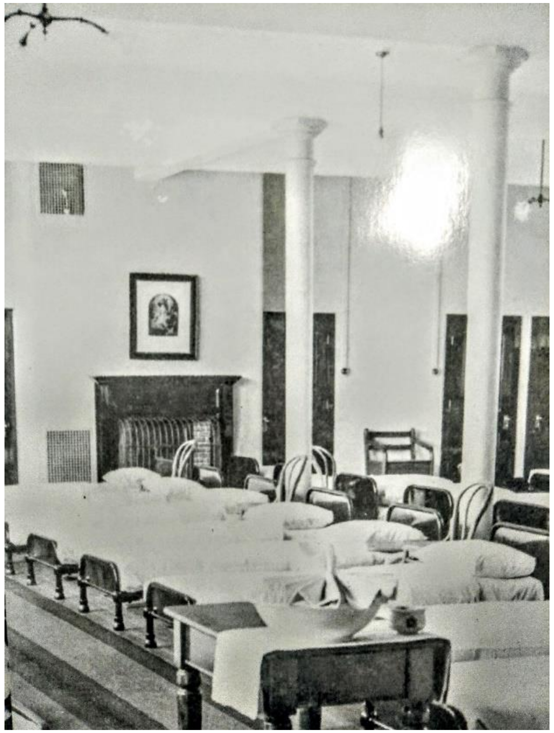


Figure 9 - Interior view of one of the wards (date not available), with electrical lighting, fireplace and ventilation vents visible (Fussell, 2019)

The electricity supply would have been generated independently by the institution from its steam engine Bellis and Morcam powered electric generator sets (City of Cardiff, 1918, 51). In 1920 a possible evacuation of the hospital was debated for the Electric Lighting and Tramways Committee to service repairs due to wear and tear of the Engineering Plant during the War office occupation of the Cardiff City Mental Hospital, suggests that the building was still self-sufficient (City of Cardiff, 1920, p41).

From 1948 the minutes indicate the proposed supply of electricity to the mental hospital may be in correspond with the nationalisation of the grid, and of the health service from the *National Health Service Act* in 1946 (City of Cardiff, 1948, p616).

Heating and Ventilation

The result of an environment in Britain that lacks extreme cold or extreme heat resulted in the commonest form of heating being generated by an open coal fire and ventilation through the opening of windows. The hospital noted in their annual report in 1928 that 1,477 tons of steam coal were consumed from April 1924 to March

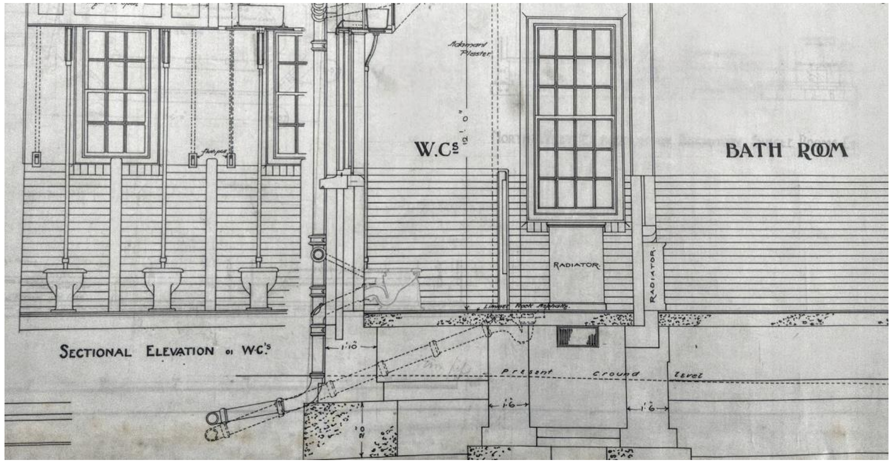


Figure 10 - Drawing of bathroom plan with radiator and plumbing services (Oatley and Skinner, 1902)

1925 from powering ofheating, cooking, laundry etc. (City of Cardiff, 1928, p32).

Fireplaces were often grouped together so that separate flues could be carried up together into a common chimney stack of which also created an up draught for ventilation. On the plans drawn in 1902 by George H Oatley and WS Skinner shows that the hospital had multiple methods of heating with radiators shown in the bathrooms and wards alongside open hearths. This may be due to the Edwardian belief that the open fire was crucial to the ventilation of the room, a room temperature over 55 degrees

Fahrenheit or 12°C was believed to be unhealthy it also served as a decorative but with function (Long, 1993, p99). Although may be directly related to the plenum form of ventilation. The contained hearth opening in a chimney was usually finished with splayed sides to maximise the flow of combustion air from the room into the grate.

The height of the opening over the fire was often limited to 750mm so cold air couldn't easily pass up flue without encountering the fire, hence curving flues to prevent rain and sleet falling onto the fire and to stop downdrafts (Taylor 1991, p160). The design of buildings fireplaces as visible in figure 11, shows that chimneys were often grouped together, on floor levels but also back to back so that separate flues could be carried up together into a common chimney stack. Grouping flues also increased their efficiency because an up draught of combustion air in one flue induced a similar movement of air in adjoining flues, this phenomenon was sometimes exploited as a means of ventilation in rooms (Taylor, 1991, p161).

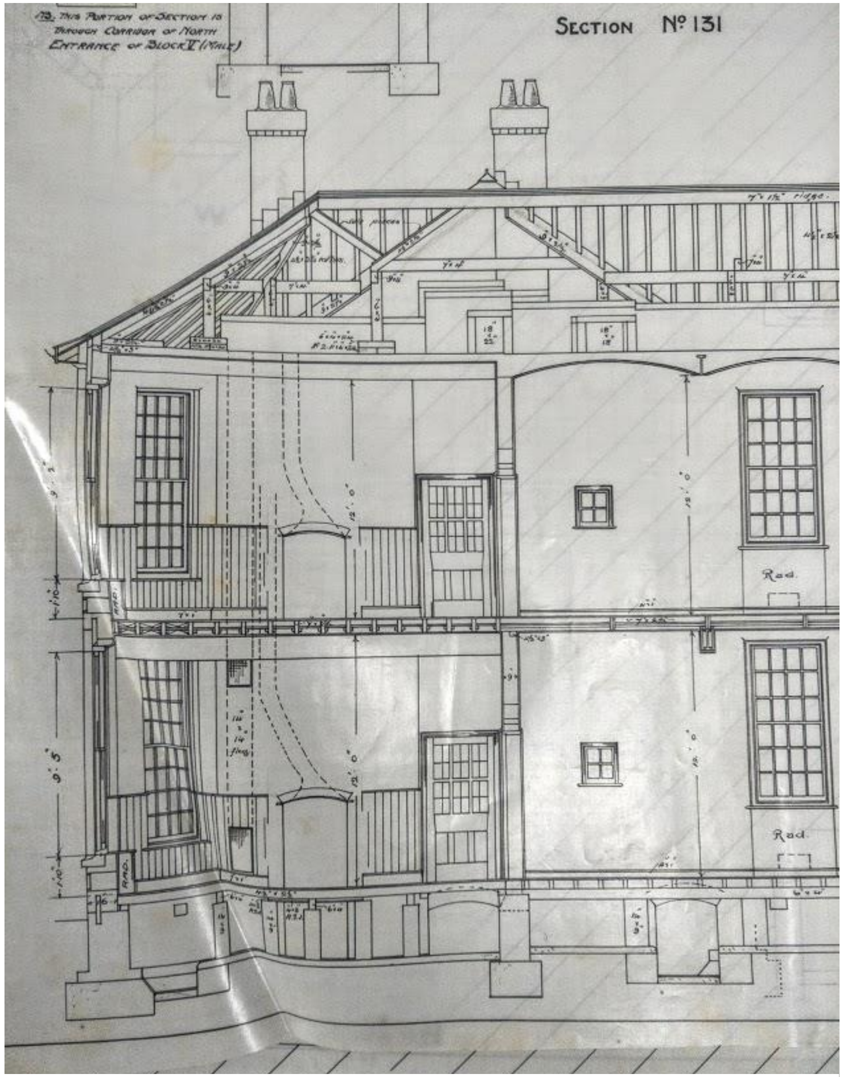


Figure 11 - Elevation view of the wards with details of the chimney flues and plenum ventilation system (Oatley and Skinner, 1902)

To ensure efficiency of flues in carrying away smoke and fumes, a gently curving route for a flue not exceeding 45° the large radius built in a curved form in corbelled brick construction. A vertical air duct about 150mm square wide was situated alongside the chimney that ran up the wall then terminating in roof space. When the fire was lit gasses in the chimney flue heated the surrounding brickwork and the air in the neighbouring ventilation duct and induced it to rise and so drawing stale air out of the room (Johnson 2006, p156).

In 1890's architects Hare used Ashwell and Nesbit's patent 'Leicester Plenum System' at Staffordshire County Hall's main purpose to provide each council member with 1000 cubic feet (28.3 m3) of fresh air per hour (Fellows, 1999, p118). Fresh air was admitted from the exterior at ground floor level and drawn by means of electrically powered fan to a heating chamber in the basement. Here is passed through screens of coconut fibre as a filter for larger contaminants. Then passed over a battery of heating pipes from where it travelled along wooden ducts built into the walls admitted though grilles well above head height. The air was extracted by a fan located above the dome or returned by ducts to the heating chamber in the basement, in hotter weather the heat would be turned off. Open fires would still be in use in certain rooms, two boilers in the basement fed low pressure steam via a distributor to the heating batteries for the plenum system and various other zones of the building where radiators were the main means of heat transfer (Fellows, 1999, p118).

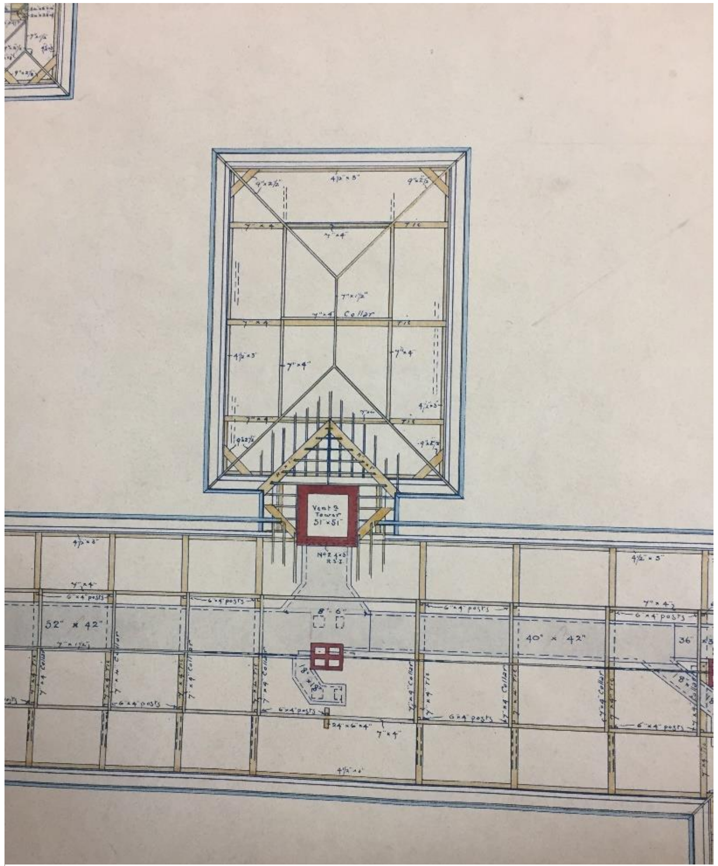


Figure 12 - Plan of ventilation ducts in located in the roof, that would release contaminated air through the vents (Oatley & Skinner, 1902)

Edwardian hot-water control heating systems operated on the same principles through gas and oil or solid fuel fired boiler supplying hot at low pressures to metal panel radiators via metal pipes (Taylor 1999, 160). Large diameter steel pipes to cast metal column radiators to the cast-iron boiler was coke fired. Circulation of water achieved by water attaining pressure necessary to raise it to the highest radiators and gravity relied to return it to the boiler. A looming image on the skyline, the 45-meter-high water tower had an important purpose to the functioning of the water systems. Most importantly providing the pressure to deliver potable water through the building, it contained a water tank constructed at a height to sufficiently pressurize the water distribution system for the distribution of the water. In an emergency it also provided water storage for fire protection. Due to gravity, the hydrostatic pressure produced by elevation of water was able to push the water into the distribution systems throughout the day and a pump typically refilled the tower during the night. The process of the water level falling in the peak hours of the day and filling up during the night results in the continual flow of water, stopping it freezing in colder weather.

In 1938 the City councils engineer reported on the operation of the Bennis Mechanical Stokers regarding their minimum upkeep costs, low fuel bills and cleanliness ‘Dealing with the maximum load demands of the Hospital steam services during the winter months – working of these furnaces with a shallower depth of fire, thereby

Figure 13 Photgraph of newer plant system likely to be gas powered on the closing of the hospital (Whatever’s Left, 2019)

securing a more liberal air space for adequate combustion, together with other adjustments to the feed -mechanism have been completely justified both on grounds of efficiency and economy' (City of Cardiff, 1938, p333). The system proved to provide an adequate steam supply to the Electric Generating Sets, Domestic Hot Water Supply, Heating System with very little variation temperatures.

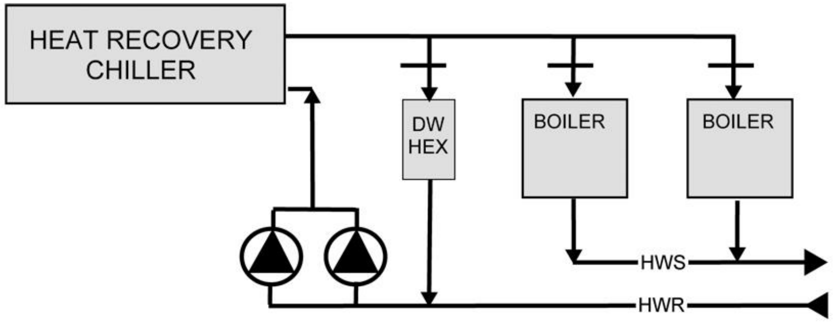


Figure 14 - A diagram of a heat recovery system (Wirges et al, 2016)

Details of later modifications to the energy systems have not been found in later council munities but may be located within other hospital documentation. A photograph on the plant room can be found on the Urban explorers website 'Whatevers left' and shows what may be a multi-combinations system that would have serviced the heating system and hot water allowing water to be returned and reused. In Figure 14 the image below shows a simplified version of how this may operate, water being released from the boiler into the hot water system (HWS) and being returned (HWR) to be processed through the cycle again (Wirges et al, 2016). In 1939 it was reported that the cast iron domestic hot water tank located within the water tower at the hospital had burst, and stated that tanks had a capacity to hold 5,500 gallons of water, and that replacing was required with a pressed steel tank (City of Cardiff, 1939, p143)

In 1939 City Engineer also suggests double compartment storage tank to be installed to maintain definite and continuous supply of water to the various departments of the hospital. By raising the level of the new tank and the cold water supply another 30 feet up to the fourth floor of the tower; this will naturally increase the pressure in the existing hot water mains. This additional pressure about 13lbs per square inch may cause pressure eon pipe joints would require servicing every 30 years (City of Cardiff, 1939, p154).

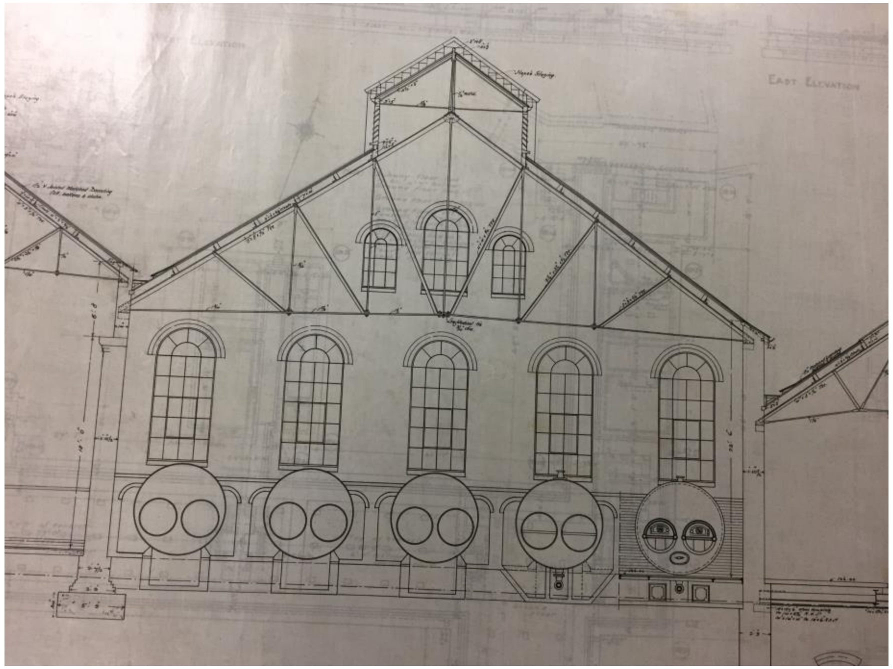


Figure 15 - Plan elevation of the boiler room including the Bellis and Morcam steam Engines (Oatley & Skinner, 1902)

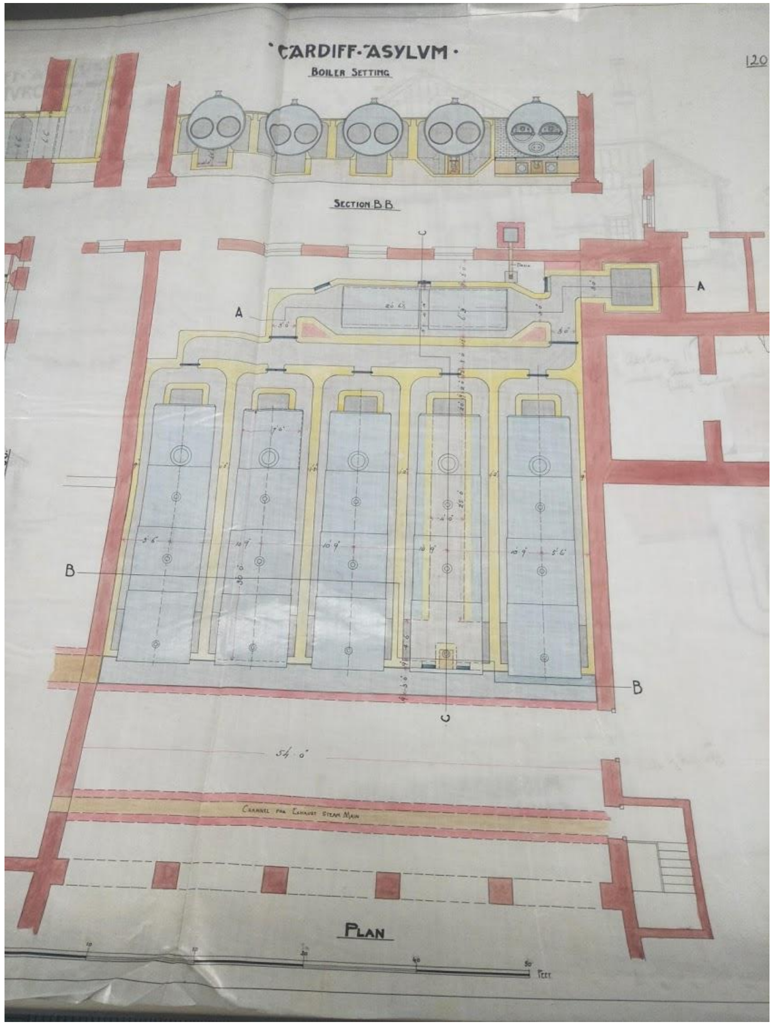


Figure 16 - More detailed plans in colour of the steam engines and their systems (Oatley & Skinner, 1902)

Water

Only in the early years of 20th century did piped services become a standard provision for urban dwellings. In 1894 standards set by public health legislation and Public Health Act 1975 urban authorities received power to make by-laws relating to drainage (Johnson, 2006, p48). The practical consequence of these powers were the development of fowl and storm water drainage for every new dwelling and connection to public sewage systems. During the Edwardian period all new houses in England and Wales required to have an adequate means of fowl – water disposal at design stage. Before commencing work of site developers required to submit plans illustrating their proposals to the local authority. This may be why the plans for the drainage system are available in the archive whereas electrical system is not. The council minutes show as previously mentioned that gas lighting was still being considered in 1907-08, of which design as installation of these may have taken place later.

The Council minutes indicate that water mains were extended from new streets built off Whitchurch Road, of which from 1907 – 1908 35 new services were created. The water being directly supplied by Cardiff Waterworks likely supplied from either Heath or Rhiwbina Weir (City of Cardiff, 1908, p78).

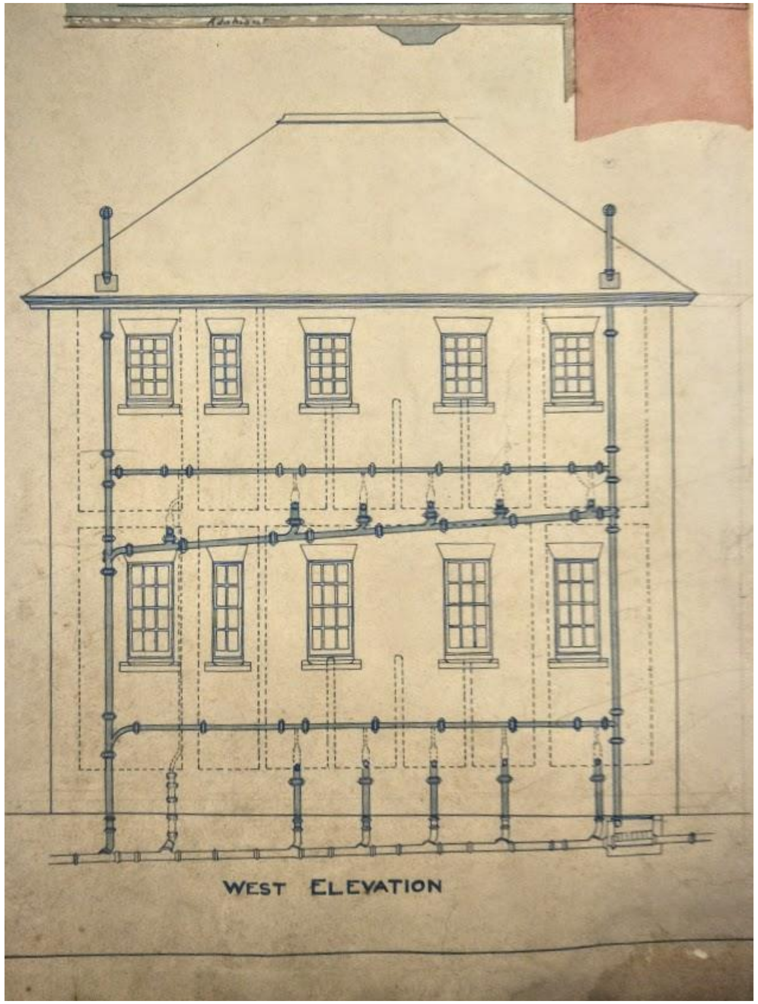


Figure 17 - West elevation of the exterior drainage routes (Oatley & Skinner, 1902)

As shown previously in figure 4, large amounts of water were used not just for day to day services but for treatments as well such as continuous baths used to treat patients suffering from insomnia, a patient could expect a continuous bath treatment to last from several hours to several days, or sometimes even overnight (London Asylum, 2009).

Alternative use

U-values have been created to understand how the windows, doors and wall fabric currently preform, showing what changes or insulation would be required for the building to reach guidelines. Understanding these will help towards the potential proposals of alternative uses for the hospital.

The fabric of the building would require adjustment to comply with current building regulations, under section 6 of Part L1b Welsh planning regulation for the material change of use as shown for

Table 7: U-values ($W/m^2.K$) for windows and doors			
Controlled fittings	(a) Maximum U-values[20] for new and replacement windows and doors	(b) Alternative maximum U-values[20] for replacement windows	(c) Threshold U-values[20] for retained windows and doors
Windows, roof windows and rooflights	1.6 or WER Band C[21]	1.2 centre pane or low-e secondary glazing	3.3
Doors	1.6 or DSER Band E[21]	1.2 centre pane	3.3

Figure 19 - Part L1bU Value tables for retained windows and doors (Welsh Government, 2014, p20

fabric in Figure 18 (Welsh Government, 2016, p19). The buildings external wall for example built of typical brick cavity wall ; 105mm outer brick, 50mm clear cavity, 22mm thick inner skin with additional rendered finishes has been calculated to retain a U-value of 0.88 W/m2.K as show through its build up in Figure 20. To reach compliance additional insulation would be required. In the case of the roof and floors we can assumptions can be made the typical U-value of the pitched roof would be 2.3 assumptions can be made due to the age of construction and due to the amount of insulation to have been added unknown (BRE, 2012, p136). The results for a typical solid wood door for the external and internal areas of the building have a result of 3.0 which reach the current threshold for retained doors (Welsh Government, 2016, p20). the single glazed sash windows currently fall below the required standards and would

Table 6: U-values (W/m^2.K) for retained thermal elements		
Elements[16]	(a) Maximum U-values[17] for retained fabric	(b) Limiting U-values[17] for retained fabric
Walls – cavity insulation[18]	0.55	0.70
Walls – external or internal insulation	0.30	0.70
Floors[19]	0.25	0.70
Pitched roofs – insulation at ceiling level	0.16	0.35
Pitched roofs – insulation between the rafters	0.18	0.35
Flat roofs or roofs with integral insulation	0.18	0.35

Figure 18 - Part L1bU Value tables for retained thermal elements (Welsh Government, 2014, p19)

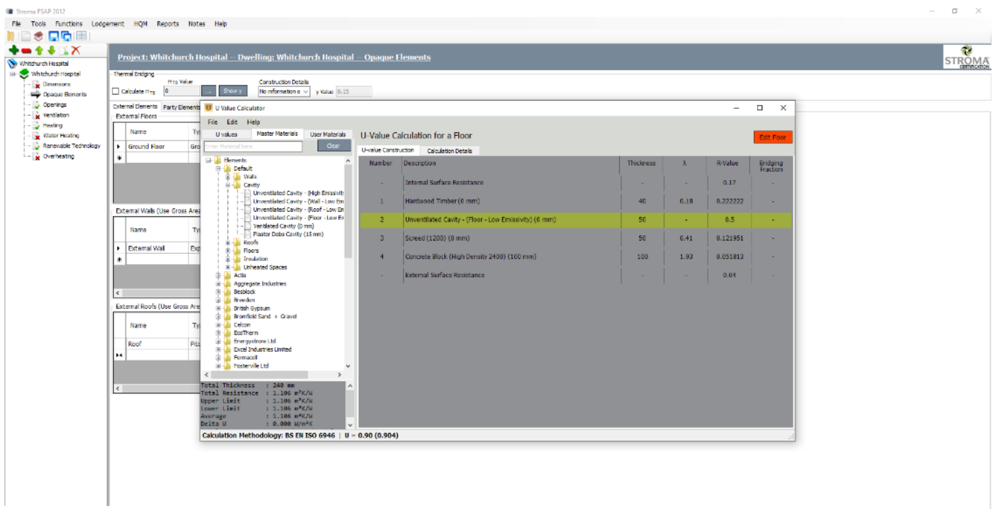


Figure 20 - FSAP calculation result of the external wall build-up (Fussell, 2019)

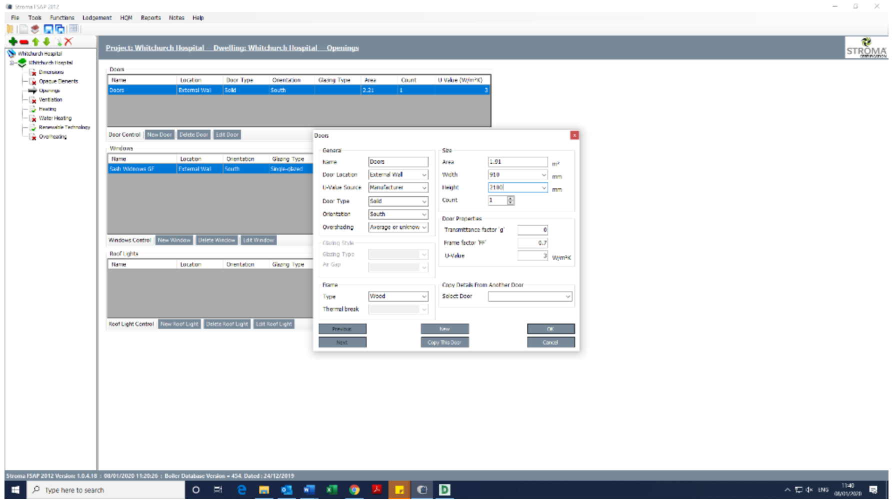


Figure 21 - FSAP calculation result of the doors (Fussell, 2019)

require replacement windows and doors should be draught-proofed units.

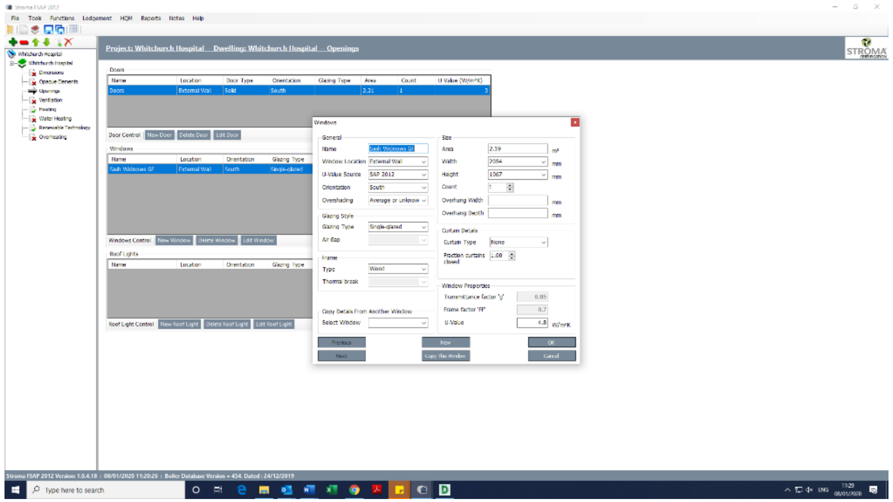


Figure 22 - Figure 21 - FSAP calculation result of the doors (Fussell, 2019)

Conclusions

The results of the U-Value calculations and the predicted performance of the fabric, suggest that additional methods would need to be implemented to allow the fabric to pass compliance with current legislation. Ensuring rooms within are able to retain a comfortable atmosphere to the expectations of peoples thermal comfort. Care also must be taken to the buildings carbon footprint, with Welsh Government recently releasing plans for buildings to operate close to zero emissions by 2050 (Welsh Government, 2019, 81). This will require further research of how to heat and power the building. By ensuring the material fabric is thermally efficient and able to perform well, it will ensure that the amount of energy expending on its day to day use is minimal. From history the institution has always retained a level of self- sufficiency from its farming and generating its own power for it boiler, hot water services. It may be possible to take elements of how the building previously operated in the early 1900'S to inspire plausible options for its future domestic or commercial use.

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Images

Figure 1, 7, 8: Authors Photos taken 2019.

Figure 2: Digimaps. 2019. Ordinance Survey Map 1920, Whitchurch. Grid reference ST 14356 80087. Accessed 20/11/2020; https://digimap.edina.ac.uk/roam/map/historic

Figure 3: Google maps. 2020. Satellite image of Whitchurch: Accessed 11/01/2020 [available at https://www.google.com/maps/search/whitchurch+cardiff/@51.5158717,-3.231449,906m/data=!3m1!1e3]

Figure 4 & 5 - City of Cardiff. 1928. *The Mental Hosptial; Twenty-first Annual Report, for the year 1928.* Cardiff: S Glossop & Sons, Ltd. Page - 32

Figure 6 ***:*** Guenther, R. 2013. *Sustainable healthcare architecture.* Second edition. arg. Hoboken, New Jersey : John Wiley & Sons. P xvii.

Figure 7: Source and date unknown. *Interior view of one of the wards*. Authors own. 2019.

Figure 13 - Whatevers Left. 2019. *Whitchurch Hospital, Cardiff.* (Accessed 12/01/2020) [Available at - https://www.whateversleft.co.uk/asylums/whitchurch-hospital-cardiff]

Figure 14 – Wirges, W et al. 2016. *Consulting-Specifying Engineer. Case Study: hospital boiler systems.* (Accessed 12/01/2020). [Available at - https://www.csemag.com/articles/case-study-hospital-boiler-systems/]

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Figures 18 & 19: Welsh Government. 2014. *Building Regulations guidance Part L. Section 6 – Material Change of Use.* Page – 19, 20 (Accessed 03/01/2020) [Available at:https://gov.wales/sites/default/files/publications/2019-05/building-regulations-guidance-part-l-conservation-of-fuel-and-power-2014-l1b-existing-dwellings.pdf]

Figures 20, 21, 22: FSAP calculation results of fabric, by author. 2019. *FSAP Software 2012.*