A PROPOSAL TO INCREASE THE ENERGY EFFICIENCY AND SUSTAINABILITY OF LIGHTING IN THE STUDENT ACCOMODATION BUILDING, UWTSD LAMPETER

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1.0 Introduction

The purpose of this report is to understand the different ways that the student accommodation on the campus of the UWTSD Lampeter, can be upgraded, to create a more energy efficient, and sustainable building. The budget quoted for the whole project is £2.5m. This report is going to focus on lighting specifically. The report will explain previous systems regarding lighting, and explain new modern systems that are available, and if they should be recommended.
There are two specific blocks that will be used to refer to. These are blocks B and C. Floor plans of these can be found in *appendix 1 with blocks B and C labelled clearly (both ground and first floor).

2.0 Current systems

2.1 Lighting currently in place at UWTSD, Lampeter

Currently, the UWTSD Lampeter student accommodation building is derelict, and has been for some time. All systems within the building are outdated and are required to be upgraded before residents move in. The lighting currently being used is halogen bulbs or fluorescent tube lighting, which since the introduction of LED's, are outdated. Figure 1 and 2 show images of current lighting.

Figure 1: Example of Halogen Lighting

Figure 2: Example of Fluorescent Lighting

Not only is the current lighting system low in energy efficiency, the amount of light being emitted is not suitable for each room size. All the rooms in blocks B and C contain only 1 light. This will result in using secondary lighting, such as reading lights, lamps, etc. This will make the building more energy inefficient. In some rooms this can be acceptable, if the natural light is being enhanced, but for north facing rooms for example, this will not be as easy. All the lighting, whether in communal or private rooms, is operated via separate switches. This means that there is a potential for students to leave lights on, whether accidentally for long periods of time, or deliberately because they intend to return. Either way using a simple motion detector system in specific areas to switch the lights on to a set (but variable timer), could prove very energy efficient.

2.2 Potential issues regarding the student accommodation building

The building in question is currently listed as grade II*. It is listed due to "special architectural interest as an exceptional group of educational buildings of considerable national historic importance" (Cadw, 2012). Grade II* buildings are said to be of 'particular interest' and make up 5.5% of listed buildings (LPOC, 2017). The listed status means that restrictions are in place to secure the historic significance. Changes to the physical building itself are prohibited and illegal. Not following the restrictions correctly could mean, in extreme circumstances, a custodian sentence for offenders.
However, rooms can be altered within the building and can be installed as a 'cube' within the old room (Heritage-consulting.org, 2017). This means that in regard to the student accommodation building, a new ceiling, could be installed below the old one, to house new upgraded lighting systems without changing the physical building in the void between the two ceilings.

3.0 How do you measure brightness and energy usage in lighting?

3.1 Understanding lumens and watts

The amount of light in a room is measured in lumens. The official definition of lumens is "a unit of luminous flux in the International System of Units, that is equal to the amount of light given out through a solid angle by a source of one candela intensity radiating equally in all directions" (Lumens.com, 2018). Therefore, more lumens, means more light.
Watts is the measurement used to analyse the amount of energy being consumed per bulb. If a bulb for example is 80 watts (80W) that means it is drawing 80W of energy every second that bulb is in use. The higher the wattage does not mean the brighter the bulb. Figure 3 explains more regarding the number of lumens in comparison to the number of watts.

How Many Lumens Do You Need?
More Lumens = More Light

If you used to buy this in incandescent	Look for this much light in lumens	LED (most efficient)	CFL (more efficient)	Halogen (more efficient incandescent)
100 W	1600	up to 22 W	up to 26 W	up to 72 W
75 W	1100	up to 20 W	up to 23 W	up to 53 W
60 W	800	up to 12 W	up to 15 W	up to 43 W
40 W	450	up to 9 W	up to 11 W	up to 29 W

Lumens vs Watts: Output and wattages based on most common products available for each medium screw-based light bulb. Actual light output may vary by product.

Figure 3: (Lumens.com, 2018)

3.2 The different types of bulbs

The most energy efficient type of bulb is LED (Light-Emitting Diode). This, although more expensive to buy, uses the least number of watts and will last longer than the other bulb types. LED is still a relatively new type of bulb, and they only started incorporating them in consumer products in 1978 (Energy.gov, 2018). Positive aspects of LED's include life expectancy, energy usage, design flexibility, etc. (Energy.gov, 2018). The negatives include cost, many are not dimmable, possible compatibility problems with transformers.

CFL is the most recently re-invented bulb. This is a Compact Fluorescent Lamp. This bulb was re-invented in 1976 when Edward E. Hammer produced a CFL bulb in a spiral shape (Energy.gov, 2018). This was more energy efficient due to the reduced loss in heat. Halogen for example, loses lots of energy through giving off heat, and therefore does not last as long as comparable LED and CFL bulbs. The main purpose for choosing CFL is the price. It is a good compromise between price and energy savings.
Halogen is one of the oldest types of bulb which is becoming more obsolete with time. It is one of the least energy efficient bulbs available and lasts a matter of years. However, these can often be the cheapest bulbs available and therefore why they're still popular.
Incandescent is the original type of light bulb which is widely known to have been invented by Thomas Edison (Bulbs.com, 2018). Incandescent bulbs, like halogen are least effective in energy efficiency and will be obsolete in a matter of decades.
See figures 4, 5, 6 and 7 showing examples of a LED, CFL, Halogen and Incandescent bulbs respectively.

Figure 4, 5, 6 & 7 (Google Images, 2018)

3.3 How many bulbs are required in a room?

Previously, the amount of light in a room was measured in watts. This is not suitable and is why lumens were created. Lumens will measure the exact light in a room, whether it has come from an artificial bulb, or from natural light. For example, a south facing building in the UK can be optimised to use the natural light and therefore reduce the number of bulbs and wattage used. This is called daylight harvesting. There is no exact number of lumens that are required for a room.

4.0 Building Regulations – lighting

Compulsory Building Regulations and information in relation to lighting in new dwellings is as follows...
Interior lighting;

1. Daylight use can be regarded as any point between the window and 6m horizontally adjacent. This means that any daylight that can be enhanced will only be useable within a 6m distance from the daylight entry point.
2. All low energy light fittings should have a minimum 45 lumens per circuit watt (circuit watt meaning, the fitting behind the bulb (transformer)).
3. 75% of all lighting in new dwellings is required to be energy efficient

Exterior lighting;

Exterior lighting regulations state that all lighting must contain motion and light sensors so that

when it is daylight, the exterior lights will remain off. This also means that at night time, the lights will only come on when movement is recognised (HM Government, 2010).
These are the only regulations regarding lighting currently in use. These regulations will not be too restrictive and therefore the listed aspect of the building will be the most difficult obstacle, when renovating the building.

5.0 Student accommodation analysis and recommendations

5.1 Natural light

5.1.1 Windows (reflective window sills)

Looking at *appendix 1 you can see the size of the windows for each room. They are very small in comparison to the size of the rooms and ceiling height. This report believes that larger windows would allow the rooms to benefit more from natural light. Figure 8 shows the ground floor of block C where the windows sizes can be seen.

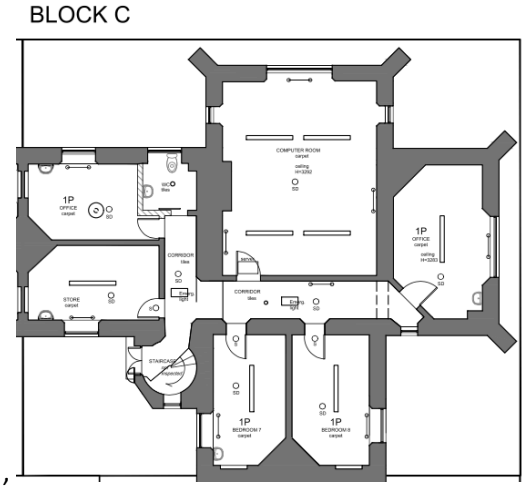

Figure 8: *Appendix 1

Unfortunately, due to the buildings listed requirements, new window openings will not be a possibility. However, there are other options. White window sill boards - Figure 9 shows an example of this.

Figure 9: (Home Improvements, 2018)

They work by reflecting the natural light into the room therefore enhancing daylight. This option is very good for rooms where there is only one window and a clean spread of light across the room would be beneficial. For the bathrooms, this is a very good option as the windows are frosted. As the

light is already reduced, using these types of window boards could further enhance the bathroom light. Also, as the boards are made from plastic, they are hygienic and easy to clean.
Looking at *appendix 1, the windows highlighted in red are the windows that are south facing, and therefore will not require the use of the sill boards as much as the north facing windows which will receive less daylight. The windows that are south facing are few, as the building is mostly north facing and it will be a recommendation to use these sill boards for all windows in both north and south facing rooms.

5.1.2 Sun pipes

Sun pipes are designed like a sky light. They work by inserting a metallic pipe that leads from the ceiling through to the roof and will bring light down and spread it through the room. See figure 10 showing an example of this, and figure 11 showing it in use in a commercial building.

Figure 10: (Sunpipe, 2018)

Figure 11: (Sterling Build, 2018)

Sun pipes are a free, highly efficient way of producing light, especially in smaller sized rooms. They are estimated to reduce lighting costs by 75% in rooms which contain sun pipes (Sunpipe [1], 2018). These can be an option for first floor rooms and would be suitable during most of the day. An issue may arise because of the listed status of the building and a request to install these would need to be made and approved by the Planning Authority. These would be most effective in north orientated rooms, but very energy efficient for south orientated rooms also. Costs for sun pipes can vary due to

the number of aesthetic options you can choose from, but an average cost of £220 per unit should be expected. On *appendix 1 we can see the first-floor plan. Block C is the largest block. If sun pipes were installed in block C, this report estimates a total cost of £2200 for 10 units (the first-floor plan in *appendix 1 shows recommendations for the positions of the 10 units highlighted in blue). We can then multiply that average cost by the 8 blocks that we have the plans for, which gives an approximate total cost of £11,000. An estimated 75% of lighting costs will be saved however, meaning that sun pipes would be a very cost, and energy efficient addition.

5.2 Artificial lighting

5.2.1 Automatic lighting (movement sensor), light sensor

Automatic lighting is often used in commercial buildings and is used in certain rooms at domestic properties. This would be an ideal solution to reduce the energy usage at the student accommodation. Sensors are recommended to be installed within the communal areas and bathrooms. Bedrooms would be more suited to a manual, on, off, light switch, where more time is spent. Bathroom light switches are commonly left on by mistake so this system would rule out this problem. Motion sensor lights have been measured to save up to 30% energy in some commercial buildings (YouGen UK, 2018). This can be hugely beneficial in financial and energy saving terms.
A light sensor will be in place in the bathrooms which will mean that if sufficient natural light is available, the lights will not come on. A manual override switch will be available to use if necessary or preferred.

5.2.2 Room lighting and positioning

From the research mentioned earlier in this report, the ideal bulbs to use will be LED's. This is due to their long use life and the highest energy efficient bulb available, meaning long term energy cost saving. The negative impact is the initial cost and lack of dimming. This report believes the best way to optimise light is as follows;

Bedrooms – 4 non-dimmable LED spotlights (wall switch), 2 lamps, 1 centre light (wall switch)
Bathrooms – 4 non-dimmable sensor-activated lights, mirror light
Hallway's – 4-8 non-dimmable spotlights sensor activated

All these lights are recommended to be LED. The centre light has been put in place to give an even glow of light around the room when necessary. As the bedroom ceilings are high, the centre light would be a pendant light, which will suspend from the ceiling from a minimum distance of 7 feet from the ground to avoid collisions whilst allowing the best possible spread of light.
*Appendix 2 shows an enlarged image of block B, with the lights marked and labelled to show the recommended areas to install in red (lamp positions in bedrooms not shown). These rooms will all require undertaking the 'cube' system as mentioned previously. This is so the new light fittings can be put in place to take the LED bulbs in the ceiling.

5.3 Solar panels

Solar panels would be a highly energy efficient way of running the student accommodation. These, usually placed on a roof but can be placed on flat ground, are a way of harnessing the suns energy and transferring it into electrical power. See figure 12 showing an image of solar panels.

Figure 12: (NetZeroRenewables, 2018)

This would be a suitable option if a spare area of ground was available to install these. Installing the panels onto the roof of the student accommodation would be difficult due to its listed status and many surveys and requests would be required. This report believes the most cost effective, hassle free option would be to attempt to place as many of these solar panels onto a spare strip of land that receives good sun coverage. This would be a good addition to the other options mentioned in this report.

6.0 Estimated energy and cost savings

6.1 Average bulb cost savings

As mentioned earlier in this report, the current bulbs which are being used are less efficient, but cheaper than the latest form of bulbs, LED's. However, will LED's save money? See figure 13 which shows the estimated energy cost and financial savings if both a halogen and LED were used on an average of 5 hours a day per year (5 hours being the average time used per bulb per day).

Light Bulb Type	**5w LED Spotlight**	**50w Halogen Spotlight**
kWh Used Per Year	9.13	91.25
Cost of Electricity Per Year (@£0.15/kWh)	**£1.37**	**£13.69**

Figure 13: (Horridge, 2018)

This shows a saving of £12.32 per bulb per year if the LED recommendation is used. However, this is only over the course of one year. Due to LED's lasting much longer than halogens, the cost over a longer period would be much different. See figure 14 which shows the costs and cost savings involved in up to 20 years of usage.

	5w LED Yearly Costs			50w Halogen Yearly Costs		
	Electricity Cost	Cost of Bulb	Cumulative Cost	Electricity Cost	Cost of Bulb	Cumulative Cost
Year 0	£0.00	£59.94	£59.94	£0.00	£9.00	£9.00
Year 5	£8.22	£0.00	£101.04	£82.13	£0.00	£437.63
Year 10	£8.22	£0.00	£142.14	£82.13	£9.00	£875.25
Year 15	£8.22	£0.00	£183.24	£82.13	£0.00	£1,303.88
Year 20	£8.22	£0.00	£224.34	£82.13	£9.00	£1,741.50
Total	**£164.40**	**£59.94**	**£224.34**	**£1,642.50**	**£99.00**	**£1, 741.50**

Figure 14: (Horridge, 2018)

Over the space of 20 years, each LED bulb is shown to save £1,517.16 (Cumulative cost of using Halogen for 20 years – cumulative cost of using LED for 20 years). The costs table shown in figure 14 shows that for every 1 halogen bulb, 7.7 LED bulbs can be used to match its cost. Figure 13 can be used to calculate that the kWh saving of using a LED bulb over 20 years compared to a Halogen amounts to 1,642.4 kWh. This energy saving totals a cost saving of £12.32 per bulb per year (1642.2kWh saved x average kWh cost [15p] divided by 20 equals the saving per bulb per year). Due to this report, not being able to obtain current energy costs from the UWTSD, Lampeter, an average cost of 15p per kWh has been used (UK Power, 2018). These calculations and figures show that the initial outlay of purchasing LED bulbs will be worth it for the long-term both from a financial and energy saving point of view.

6.2 Block C cost savings

*Appendix 1 shows the plans for block C on the ground and first floor. The total estimated bulb costs per year over a span of 20 years can be seen in figure 15 below.

	Reccomended LED savings			Current system		
	5W LED Yearly Costs			50W Halogen yearly cost		
	Electricity cost (15p/kWh) (based on 5 hour usage per day)	Cost of bulb (£5 per bulb)	Cumulative cost	Electricity cost (15p/kWh) (based on 5 hour usage per day)	Cost of bulb (£1.50 per bulb)	Cumulative cost
Year 0	£0.00	£300 (60 bulbs)	£300.00	£0.00	£45 (30 bulbs)	£45.00
Year 1	£98.64	£0.00	£398.64	£234.66	£0.00	£279.66
Year 2	£98.64	£0.00	£497.28	£234.66	£45 (30 bulbs)	£559.32
Year 3	£98.64	£0.00	£595.92	£234.66	£0.00	£793.98
Year 4	£98.64	£0.00	£694.56	£234.66	£45 (30 bulbs)	£1,073.64
Year 5	£98.64	£0.00	£793.20	£234.66	£0.00	£1,308.30
Year 6	£98.64	£0.00	£891.84	£234.66	£45 (30 bulbs)	£1,587.96
Year 7	£98.64	£0.00	£990.48	£234.66	£0.00	£1,822.62
Year 8	£98.64	£0.00	£1,089.12	£234.66	£45 (30 bulbs)	£2,102.28
Year 9	£98.64	£0.00	£1,187.76	£234.66	£0.00	£2,336.94
Year 10	£98.64	£0.00	£1,286.40	£234.66	£45 (30 bulbs)	£2,616.60
Year 11	£98.64	£0.00	£1,385.04	£234.66	£0.00	£2,851.26
Year 12	£98.64	£0.00	£1,483.68	£234.66	£45 (30 bulbs)	£3,130.92
Year 13	£98.64	£0.00	£1,582.32	£234.66	£0.00	£3,365.58
Year 14	£98.64	£0.00	£1,680.96	£234.66	£45 (30 bulbs)	£3,645.24
Year 15	£98.64	£0.00	£1,779.60	£234.66	£0.00	£3,879.90
Year 16	£98.64	£0.00	£1,878.24	£234.66	£45 (30 bulbs)	£4,159.56
Year 17	£98.64	£0.00	£1,976.88	£234.66	£0.00	£4,394.22
Year 18	£98.64	£0.00	£2,075.52	£234.66	£45 (30 bulbs)	£4,673.88
Year 19	£98.64	£0.00	£2,174.16	£234.66	£0.00	£4,908.54
Year 20	£98.64	£300 (60 bulbs)	**£2,572.80**	£234.66	£45 (30 bulbs)	**£5,188.20**
				Total saving using new system = £2615.40 over 20 years		
Notes	60 LED bulbs have been used in the table, which is the reccomended number from the report.					
	30 Halogen bulbs have been used in comparison, which is the number of bulbs in block C currently in use.					
	This means that a perfect comparison has been undertaken from the current Halogen system, to the reccomended LED system.					
	This table has not taken into account inflation in LED bulbs, Halogen bulbs or the cost per kWh					
	Bulb, energy costs and ratios have been sourced from the following: (TheGreenAge, 2018)					

Figure 15

The costs in figure 15 have been calculated for block C only and show a 49.6% cost saving. The cost savings do not end there however. If the Sun Pipes are fitted, then there is a potential for up to an extra 75% energy cost savings. If we recalculate this using a conservative 50% energy saving from the Sun Pipes, the total energy costs would equal £1,961.55 per 20-year period (50% energy saving on 50% of total energy cost. This is due to the Sun Pipes only being effective on the first-floor rooms). These figures are all approximate as other recommendations would improve the cost savings such as the sill boards and solar panels. If we multiply the energy savings by the 8 blocks that we have the plans for, that totals energy savings of £15,692.40 or, £784.62 per year for all blocks A-H.

7.0 Conclusion

To conclude – This report has analysed all the potential and appropriate ways to enhance the light in the student accommodation building. The 'listed' status would be the most problematic issue, but it has been decided that the best course of action would be to create a 'cube' effect in each room to preserve the historic building. The idea is that a new ceiling would be placed on top of the old one with a void. This would allow new light fittings to be installed to take the new LED bulbs which have been recommended. The ceiling height would therefore be marginally lower with this system in place. However, with the ceilings already high this wouldn't be an issue. The amount of LED lighting being used would mean that the building would comply with Building Regulations, and would have a minimum 75% of all the lighting to be energy efficient. There would be 4 LED spotlights in the bedrooms which would still be more efficient than the one halogen bulb currently in use. This was proven earlier in the document when the report stated that 7.7 LED bulbs can be used for every 1 halogen bulb. Motion detectors would also need sockets and transformers to be installed in the void, to integrate that system. This is estimated to save the building up to 30% energy costs. The plastic reflective window sills should not cause any difficulties regarding the 'listed' status of the building, or cost wise. These can be made and placed on top of the current sills, and would be beneficial to the energy saving aspect of the building as light sensors would stop the lights activating

if there was enough daylight. A manual switch would be placed in the bathroom to override if necessary. This would be on a timer, and would automatically switch off when no movement is detected in the room. The solar pipes would be an excellent addition if 'planning' permitted them. They are advised to be used in both north and south orientated rooms. This option would require surveys to be carried out on the roof and requesting approval from the Planning Authority. This report believes that it is unlikely the request would be granted, but it would still be wise to enquire. Certainly, the solar (panels, pipes) are a highly efficient option. They would be useful as they would not only reduce energy costs, but during the summer months when students are not present, they would keep generating electricity, which could be sold back to the electricity grid and thus earn money in return.

These recommendations are not only energy efficient. They would also be cost effective. One of the largest expenditures would be the initial purchase of LED bulbs. This however would be repaid over time as their life expectancy would be estimated to be 20 years. Potentially the very largest expense would be the solar panels. These however would not only pay back what had already been spent, but would also begin to save money in reduced energy costs. During the months of the year when more energy is produced then used, this electricity could be sold back to the electricity grid and earn money for the university.

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*Appendices'' included in hard copy