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(EXCLUDING REFERENCES,
TABLES & APPENDICES)

UWTSD BUSINESS CAMPUS ENERGY CONSUMPTION REPORT

ENERGY EFFICIENCY IN BUILDINGS (M5X01883)

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1.0 Introduction

On Tuesday 30th of October 2018 I performed an energy efficiency survey on the University of Wales' Business Campus in Swansea. Before the survey could start, I needed to create a suitable data collection sheet which could allow me to store data needed concisely, the data sheet I created can be found on **appendix A.1**. From my findings I will give suitable recommendations to improve the energy efficiency of the building.

This survey is important because *"Increasing energy efficiency not only allows individuals and organizations to reduce their capital and operational costs, it can also help lower fuel consumption and so reduce the emission of greenhouse gases and help prevent climate change."* (**Energy Efficiency of Buildings, 2018**)

1.0.1 Technical Data

During the survey I needed to identify key parameters within the rooms surveyed that can affect the energy usage. For example, I needed to measure the rooms dimensions to find the volume of which the room needs to be heated. I also needed to understand the thickness and layers of the external and internal walls to understand the rooms resistance to heat loss and heat gain. This wall investigation along with windows and doors will need to be used for my U value calculations that will be completed later. The type of glazing, area, thickness and fire safety aspects will all influence the resultant U values.

'U-values (sometimes referred to as heat transfer coefficients or thermal transmittances) are used to measure how effective elements of a building's fabric are as insulators. That is, how effective they are at preventing heat from transmitting between the inside and the outside of a building.' (**U-Values, 2018**)

Identifying electrical equipment found within each room was very important in understanding the energy consumption within. Each device has its own energy usage values (Kilowatt/hours) and are still using energy whilst on standby. Whilst functional these appliances contribute un-accounted for energy into the room and can cause rooms to not conform to our temperature comfort levels. Evidence of this can be found on **appendix A.13**. I needed to research each device make and model online to gain access to their technical data sheets, it was on these sheets that their energy usage values were listed.

There were many different types of rooms within the University building, for example; canteens, computer rooms, hallways and lecture theatres. Each have different functions and therefore have varying volumes and temperatures. In addition, the furniture within the rooms also used energy to be manufactured and will also use energy when recycled or otherwise discarded, this then adds to the potential energy within the envelope.

1.1 Methodology

Firstly, I measured up the room using a professional **digital laser measurer** and a measuring tape. It was important to be accurate when measuring the rooms so I made sure to measure in triangles and double check calculations. I also ensured that the laser was properly calibrated by comparing its reading to those given by the **tape measure**. The tape measure was useful to measure hard to reach places such as the cladding thickness through the external window.

Secondly, I proceeded to perform a visual study of the electronic equipment within the rooms, taking note of their make and models to research later in the investigation process. I then sort to identify plug sockets and networking ports which will give me an idea of the potential maximum energy consumption usage within the rooms through the additional implementation of devices such as phone or laptop chargers.

Ventilation and heating systems were identified to understand the air flow and convection currents within the environment, I also looked for moisture build up but by there was no visual evidence of this and I decided that the thermal camera would give a better insight. I then used a **compass** when outside the building to determine the orientation of the façade. The orientation of the façade is important because sides in constant sunlight require different insulations and can harness thermal gains through windows better. Finally, I used a **laptop** to produce a report of my results.

1.1.1 Thermal-imaging Study Method

I used the **thermal-imaging camera** to analyse the heat loss/gain both external and internally. The surface area of the building fabric and its contents emit infra-red radiation due to its temperature and condition and it is that that is picked up by the camera. Each object has different absorption, transmission, emission and reflection qualities that can affect the camera's picture. Shiny, reflective ceramics and transparent glass are examples of materials that can sometimes give tricky readings.

Useful features the camera included were 'scale' and 'laser'. For internal readings I set the adjustable scale to 18 degrees to 24 degrees because this should be the ideal internal temperature of the building to conform to our comfort levels. This scale means that anything below or over these two values will be easily visible as dark blue and bright red respectively. The laser function allowed me to target parts of surfaces more accurately. I made sure to examine all walls, window areas and room corners carefully for cold and warm bridging as these are especially prone to moisture and humidity build up as a result.

"A thermal bridge, also called a cold bridge or heat bridge, is an area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer" (Thermal Bridges, 2016)

For external readings I set the scale from 0 degrees to 10 degrees as this was just below and above the external temperatures, making any heat loss clearly visible. Windows, roof/wall junctions and wall/floor junctions are some of the main places I will look to find inefficiencies. Finally, I took infra-red pictures of inefficiencies I identified and then commented on what I believe is causing them. I have also made recommendations on how they can be improved, these can be found on **appendices 11-15**.

I also used to camera to investigate the heat input to the room from electronic devices. It was also useful to identify possible safety hazard present within the room that could so be causing inefficiencies in energy consumption, for example overheating plug sockets and fuse boxes. An example of an overheating fuse can be found on **appendix A.12**.

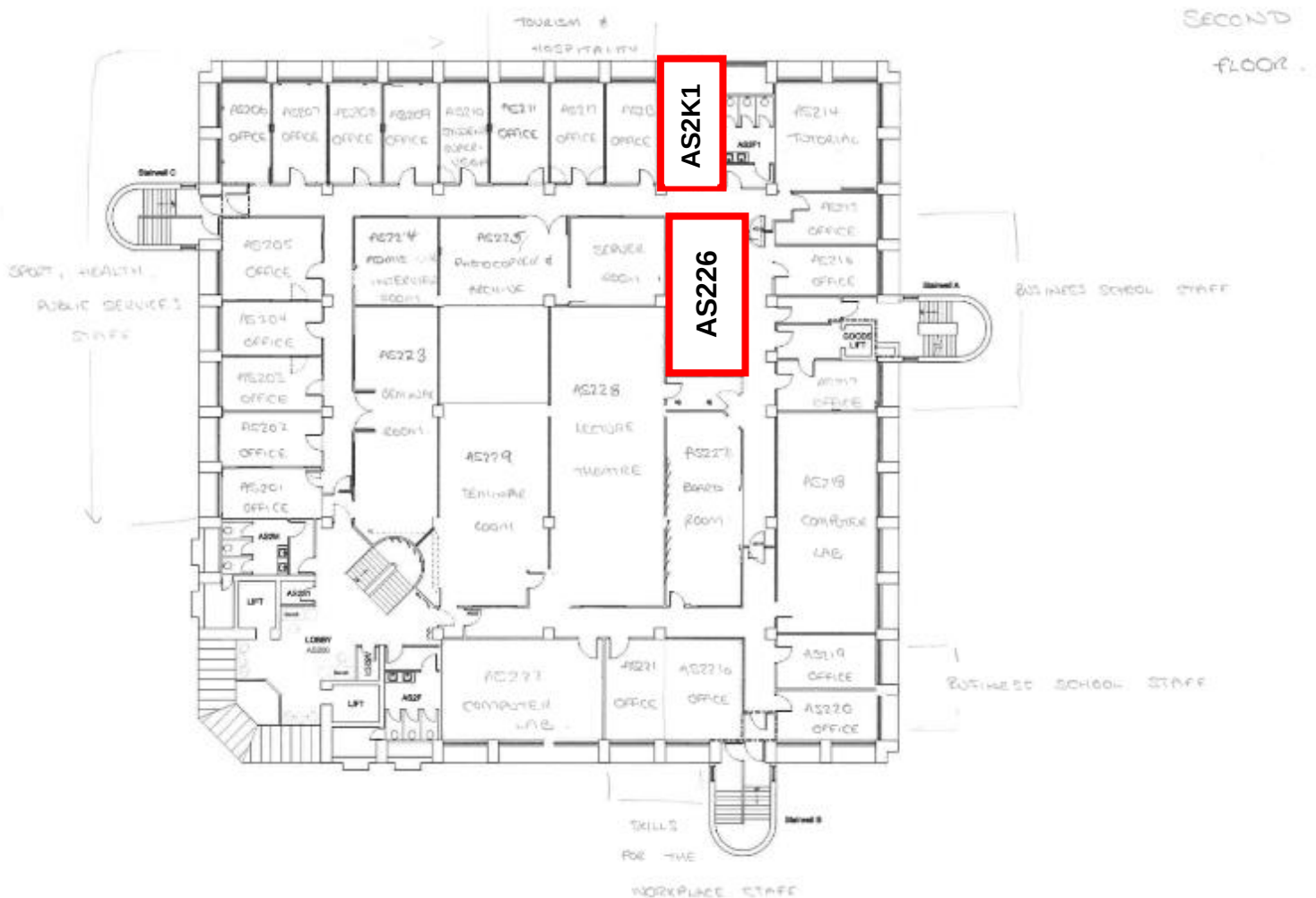
1.1.2 Equipment List

No.	Equipment	Cost	Comments
1	Measuring Tape	£10	<i>Used to double check digital readings and to measure hard to reach places.</i>
1	Fluke TiS20 Thermal-imaging Camera	£1100	<i>Used to examine heat loss and gain in the building.</i>
2	Data Collection Sheets	£0	<i>Used to store my data.</i>
1	Laptop	£200	<i>Used to research equipment and create report.</i>
1	Bosch Digital Laser Measurer	£60	<i>Used to measure rooms.</i>
1	Compass	£5	<i>Used to determine the building orientation.</i>

1.2 Energy Usage Findings

Below are the floor plans for the Business School second floor which I oversaw surveying.

* Indicates rooms which I surveyed.



1.2.1 AS2K1 Data

Area (m ₂)	3.81m + 8.73m + 1.91m = 14.45 m ²
Volume (m ₃)	14.45m ² x 2.3m = 33.24m ³
No. of Windows (Area)	1 x uPVC Double Glazed 1200mm x 1050mm window (1.26m ²)
No. of Doors (Area) (Add Detail)	1 – 44mm x 838mm x 1981mm Interior flush fire door with 16G glass (1.66m ²)
External Wall Thickness	1.3m
Partition Wall Thickness	120mm
Cladding Type	FURTHER INVESTIGATION
Building Frame	Steel
Zone	Staff Kitchen
No. of Radiators	1
Room Temperature (C°)	20 degrees
External Temperature (C°)	3 degrees

No. of Lights (Bulb Type)	1 x Fluorescent High Batten Fitting (1500mm) 50W
No. of Plug Sockets	3 Double plug sockets (BS 546) for AC (50-60 Hz) circuits up to 250V
Ventilation System	Daikin Split System Air Conditioner Cooling Capacity 1.3 to 3.2kW Heating Capacity 1.3 to 4.7kW
List of Electronic Equipment;	1x Tesco JKKC17 Plastic Kettle 1.7L. Power 2.2kW 1x Tesco Solo Microwave MM08 Value, 17L 700W maximum power output. Indesit undercounter fridge 85 x 55 x 58 cm Annual energy consumption 181 kWh . 2-Slice toaster Power 700W .

1.2.2 AS226 Data

Area (m₂)	8.68 x 4.24 = 36. 80m ²
Volume (m₃)	36.80 x 2.44 = 89.80m ³
No. of Windows (Area)	N/A
No. of Doors (Area) (Add Detail)	1 - 44x 838 x 1981mm Interior flush fire door with 16G glass (1.66m ²)
External Wall Thickness	1.3m
Partition Wall Thickness	120mm
Cladding Type	FURTHER INVESTIGATION
Building Frame	Steel
Zone	Lecture Theatre
No. of Radiators	1
Room Temperature (C°)	21 degrees
External Temperature (C°)	3 degrees

No. of Lights (Bulb Type)	8 Modular 600mm x 600mm 40W/h LED Light Panels. Max power: 320W/h.
No. of Plug Sockets	7 Double plug sockets (BS 546) for AC (50-60 Hz) circuits up to 250V 20 UPT Module Data sockets (Network Data Communication)
Ventilation System	Daikin Air Conditioning "Siesta" ACQ125A Cassette (13 kW / 44000 Btu) 240V COOLING (nominal) max. 13 kW/h. HEATING (nominal) max. 14.1 kW/h.

List of Electronic Equipment;	1 x Iiyama ProLite B2283HS-B3 22" LED Full HD Monitor Operating Power Consumption - 21.80W Standby Power Consumption - 500mW 1x Desktop 1x SMART Board X885 (SBX885) Operating power consumption is 7W/h (2W/h Standby) 1x Mitsubishi EW230U-ST Projector Max Power: 315 W/h.
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Using the information gathered I set about breaking down information, tabulating data and calculating energy usage and annual energy costs for the rooms. I also transferred my data into pie charts to make information easier to understand. All of which can be found from appendices **A.2 to A.10.**

1.3 Legislation to Consider

I must ensure that the building strictly adheres to part L of the building regulations which set out requirements for specific aspects of building design and construction. I will be most interested in approved document L2B: Conservation of fuel and power (Existing buildings other than dwellings). My final findings should support that the CO2 rating does not exceed the Target Emission Rate (TER) found in its most recent EPC (Energy Performance Certificate) Otherwise I shall have to recommend remediations.

- Regulation 26 of the building regulations states that *"Where a building is erected, it shall not exceed the target CO2 emission rate for the building"*
- Schedule 1 – Part L Conservation of fuel and power states that *"Provision for conservation of fuel and power shall be made by: limiting heat gain and losses and providing building service which are efficient, have effective controls and are properly commissioned and that information is provided so that the building can be operated efficiently."* (**Approved Document L, 2016**)

1.4 Identification of Energy Inefficiencies

All relevant thermal images taken, and their explanations can be found in the appendix;

- **Appendix A.11** AS2K1 Cold Bridging/Condensation
- **Appendix A.12** AS2K1 Fuse Box
- **Appendix A.13** AS2K1 Additional Heat Energy
- **Appendix A.14** North-West Façade
- **Appendix A.15** South-East Façade

1.5 Report Conclusion

After completing the report, I have found that there are a few things that could be changed within the building to make it more efficient. In addition, I would have surveyed differently if I were to do it again. These changes will help give a better understanding of energy loss in the building and will control unwanted variables.

1.5.1 Limitations and Inaccuracies

I would have performed a survey at the early hours of the morning to add the day-time losses. At night time the external heat losses will be more accurate because there will be no sunlight to confuse readings and it will also show how the envelope performs in colder conditions. It should also not be too windy, and the building should be dry. The orientation of the building played a part in giving inaccurate readings, when taking external pictures, the south-east sides were totally covered in sunlight whereas the north-west sides were totally shaded. Therefore, one façade was 5 degrees warmer than the other, the thermal-imaging comparison of this can be found on **appendices A.14 and A.15**.

When using the compass to study the orientation of the building there was magnetic interference between the compass and the metallic façade, this meant that my result wasn't totally accurate but could be referenced to the satellite image of google maps.

If I had more time, I could have also surveyed the above and below floor levels to see how their energy usages affected the second floor and used these results and others as part of a U value calculation for the rooms. Other tests I would have performed include;

- Air permeability & air tightness *"Air permeability testing plays a key part in establishing the energy efficiency of a building – and as regulations tighten it will be increasingly necessary to make design considerations for air tightness early on in a build. On-completion testing measures the effectiveness of your air leakage strategy by establishing routes of leakage in the finished envelope."* (**Air Permeability Testing, 2017**)

- SAP Calculations *“An SAP rating is the calculation that is required in order to produce a Predicted Energy Assessment and an On-Construction Energy Performance Certificate. Building Regulations require that an SAP calculation and a Predicted EPC is submitted for new dwellings prior to the commencement of work.” (SAP Calculations Explained, 2016)*

1.5.2 Building Efficiency Recommendations

From my survey I have found that many improvements can be made to improve the energy efficiency in the building and to lower the carbon footprint, for example;

- Maintenance and commissioning of equipment and building to make sure equipment is performing as efficiently as possible.
- Sensory HVAC unit that only turns on when required.
- Recycled furniture could be implemented to promote sustainability.
- Updated equipment could also be implemented which conform to the latest energy efficiency regulations.
- Electronic equipment should all be switched off at the power socket at night or not being used as they still use energy whilst on standby.
- Considering the entire life-cycle of products and processes, including disposal.
- Retrofitting or replacing energy-inefficient technologies.
- Educating people to be more energy efficient.

Variables that could affect the buildings daily energy usage include;

- The choice of fuels used in the building can be renewable or cheaper if chosen correctly.
- Number of staff and students present.
- Term times, weekends and holidays.
- External factors such as weather, climate, temperature.
- Building age, type of construction and defects.
- Buildings orientation and solar gains.

References

Air Permeability Testing (2016)

URL: <https://www.buildenergy.co.uk/air-permeability-testing/air-permeability-testing-the-info/>

Accessed: 1/12/2018

Energy Efficiency of Buildings (2018)

URL: https://www.designingbuildings.co.uk/wiki/Energy_efficiency_of_buildings

Accessed: 1/12/2018

Gas & Electricity Tariff Prices per kWh (2018)

URL: https://www.ukpower.co.uk/home_energy/tariffs-per-unit-kwh

Accessed: 12/11/2018

Myra Butterworth. What can I do to stop the condensation and black mould around my windows? Published 3rd March 2017

URL: <https://www.dailymail.co.uk/property/article-4252288/What-stop-condensation-black-mould-windows.html>

Accessed: 9/11/2018

Prevention of Cold Bridges (2016)

URL: <https://www.eden.gov.uk/planning-and-building/building-control/building-control-guidance-notes/prevention-of-cold-bridges/>

Accessed: 18/11/2018

SAP Calculations Explained (2017)

URL: <https://www.eden.gov.uk/planning-and-building/building-control/building-control-guidance-notes/sap-calculations-explained/>

Accessed: 1/12/2018

U-Values (2018)

URL: [https://www.designingbuildings.co.uk/wiki/U-values u values](https://www.designingbuildings.co.uk/wiki/U-values_u_values)

Accessed: 4/11/2018

Appendices

A.1 - Energy Efficiency Data Collection Sheet

Building Address	UWTSD Swansea Business Campus, High Street, Swansea, SA11NE
Client	University of Wales Trinity Saint David (UWTSD) Phone: 01792 481025
Assessor(s)	Adam Meyrick
Date	Tuesday 30 th October 2018

Floor - Room -

Room Analysis

Area (m₂)	
Volume (m₃)	
No. of Windows (Area)	
No. of Doors (Area) (Add Detail)	
External Wall Thickness	
Partition Wall Thickness	
Cladding Type	
Building Frame	
Zone	
No. of Radiators	
Room Temperature (C°)	
External Temperature (C°)	

Electrical Device Usage

No. of Lights	
No. of Plug Sockets	
Ventilation System	
List of Electronic Equipment;	

A.3 - AS2K1 Electricity Usage Calculations

Term times 2018 (Monday – Friday) 1st January – 31th December 2018

- Monday 8th January 2018 – Friday 25th May 2018 (20 weeks)
- Monday 24th September - Friday 14th December 2018 (12 Weeks)

Tesco JKCC17 Plastic Kettle 1.7L – Power: 2.2kW (**Assume 10 Kettle boils per day**) = 2.2kW/0.5 hours (**3 minutes average x 10 usages = 30 minutes running time per day, 30/60 = 0.5 hours.**)

2.2kW x 0.5 hours x 5 days x 32 weeks = **176.00kW / year.**

Tesco Solo Microwave MM08 Value 17L – Power: 700W/h (**Assume 6 Microwave usages per day**) = 700W/0.3 hours (**3 Minute average x 6 usages = 18 minutes running time per day, 18/60 = 0.3 hours**)

700W x 0.3 hours x 5 days x 32 weeks = **33.60kW / year.**

2-Slice toaster – Power: 700W/h (**Assume 4 Toaster usages per day**) = 700w/0.2 hours (**3 Minute average x 4 usages = 12 minutes running time per day, 12/60 = 0.2 hours**)

700W x 0.2 hours x 5 days x 32 weeks = **22.40kW / year.**

1500mm Fluorescent Light High Batten Fitting – Power: 50W/h (**Assume lights are on from University opening time to closing time 8am – 8pm**)

50W/h x 12 hours x 5 days x 32 weeks = **96kW / year.**

Daikin Split System Air Conditioner – **‘Assume the heating function is used from Jan – April and October – December (20 Weeks) and cooling function for May, June & September (15 Weeks) Also assume that they are active for 6 hours a day.’**

Heating Function - 4.7kW/h x 6 hours x 5 days x 20 weeks = **2820kW / year.**

Cooling Function - 3.2kW/h x 6 hours x 5 days x 12 weeks = **1152kW / year.**

5 Days a week of usage x 45 Working weeks = 225 Days of heavy usage.

A.4 - AS2K1 Results

Electronic Device	Nominal Energy Usage (Annual)	Standby Energy Usage (Annual)	Total Energy Usage (Annual)
Tesco JKKC17 Plastic Kettle 1.7L	176.00kW / year.	0W / year.	176.00kW / year.
Tesco Solo Microwave MM08 Value 17L	33.60kW / year.	26.28Kw / year.	59.88
2-Slice toaster	22.40kW / year.	0W / year.	22.40kW / year.
1500mm Fluorescent Light High Batten Fitting	96kW / year.	0W / year.	96kW / year.
Daikin Split System Air Conditioner	3972kW / year.	26.28Kw / year.	3998.28kW / year.

A.5 – AS2K1 Annual Cost

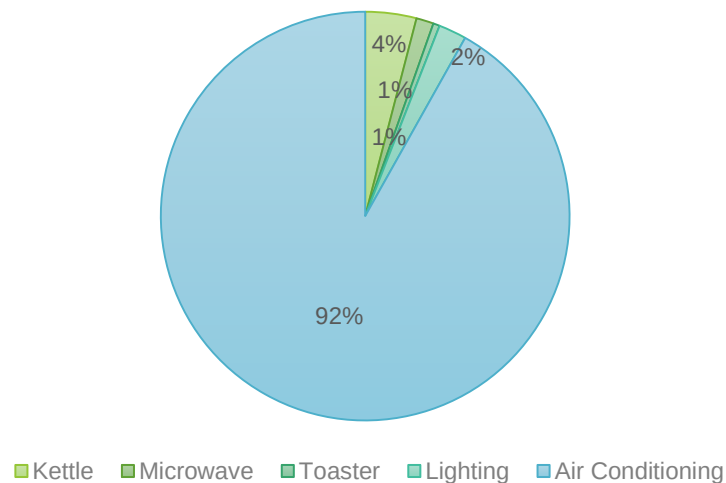
Total Energy Usage Per Year = **4,533.56 kW / year.** (4,533.56 / 365 days = **12.42kW/h** per day and 12.42kW/h / 24 hours = **0.518kW** which is the system's average power consumption)

Average kW/h energy Price = **12.499p per kWh** (ex VAT) supplier: British Gas. £0.12499 x 4,533.56kW/h = **£566.65 annual charge** to supply this room with energy.

Note; *This energy calculation is based on certain parameters being met but is based on real values. There is also potential for more energy to be consumed within the room given that there are additional plug sockets. This calculation is also based on tariff prices per kW/h accurate at 01/11/2018.*

A.6 – AS2K1 Energy Consumption Pie Chart

Energy Consumption AS2K1



A.7 - AS226 Electricity Usage Calculations

All findings consider that within term times are when most energy is consumed. Term times 2018 (Monday – Friday) 1st January – 31th December 2018

- Monday 8th January 2018 – Friday 25th May 2018 (20 weeks)
- Monday 24th September - Friday 14th December 2018 (12 Weeks)

Iiyama ProLite B2283HS-B3 22" LED Full HD Monitor – Power: 21.80kW/h (**Assume the PC is being used 8 hours a day for teaching**)

21.80kW/h x 8 hours x 5 days x 32 weeks = **27.904kW / year.**

Viglen Genie Tower PC - i7-960 3.2GHz CPU, 1TB HDD, 4GB RAM, Quadro 4000 - (**Assume the PC is being used 8 hours a day for teaching**)

38.960kW/h x 8 hours x 5 days x 32 weeks = 79.040Kw/h.

SMART Board X885 (SBX885) – Power: 7W/h (**Assume the smartboard is being used 8 hours a day for teaching**)

7W/h x 8 hours x 5 days x 32 weeks = **8.96kW / year.**

Mitsubishi EW230U-ST Projector – Power: 315W/h (**Assume the projector is being used 8 hours a day for teaching**)

315W/h x 8 hours x 5 days x 32 weeks = **403.20kW / year.**

8 Modular 600mm x 600mm 40W/h LED Light Panels - Power: 8 x 40W/h = 320W/h (**Assume lights are on from University opening time to closing time 8am – 8pm**)

320W/h x 12 hours x 32 weeks = **614.40kW / year.**

Daikin Air Conditioning "Siesta" ACQ125A '**Assume the heating function is used from Jan – April and October – December (20 Weeks) and cooling function for May, June & September (15 Weeks) Also assume that they are active for 6 hours a day.**'

Heating Function - 4.7kW/h x 6 hours x 5 days x 20 weeks = **2820kW / year.**

Cooling Function - 3.2kW/h x 6 hours x 5 days x 12 weeks = **1152kW / year.**

A.8 - AS226 Results

Electronic Device	Nominal Energy Usage (Annual)	Standby Energy Usage (Annual)	Total Energy Usage (Annual)
Iiyama ProLite B2283HS-B3 22" LED Full HD Monitor	27.904kW / year.	4.38kW / year.	32.284kW / year.
Viglen Genie Tower 1TB HDD, 4GB RAM	79.040kW / year.	32.75kW / year.	111.77kW / year.
SMART Board X885 (SBX885)	8.96kW / year.	17.52kW / year.	26.48kW / year.
Mitsubishi EW230U-ST Projector	403.20kW / year.	26.28kW / year.	429.48kW / year.
8 Modular 600mm x 600mm 40W/h LED Light Panels	614.40kW / year.	0W / year.	614.40kW / year.
Daikin Air Conditioning "Siesta" ACQ125A	3972kW / year.	26.28Kw / year.	3998.28kW / year.

A.9 - AS226 Annual Cost

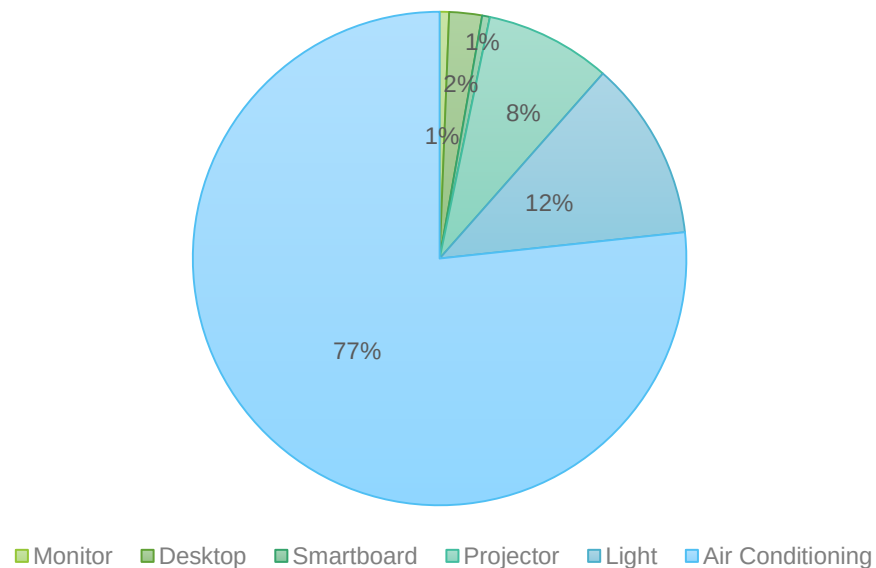
Total Energy Usage Per Year = **5,212.694kW / year**. (5212.694 / 365 days = **14.28kW/h** per day and 14.28kW/h / 24 hours = **0.59kW** which is the system's average power consumption)

Average kW/h energy Price = **12.499p per kWh** (ex VAT) supplier: British Gas. £0.12499 x 5,212.694kW/h = **£651.53 annual charge** to supply this room with energy.

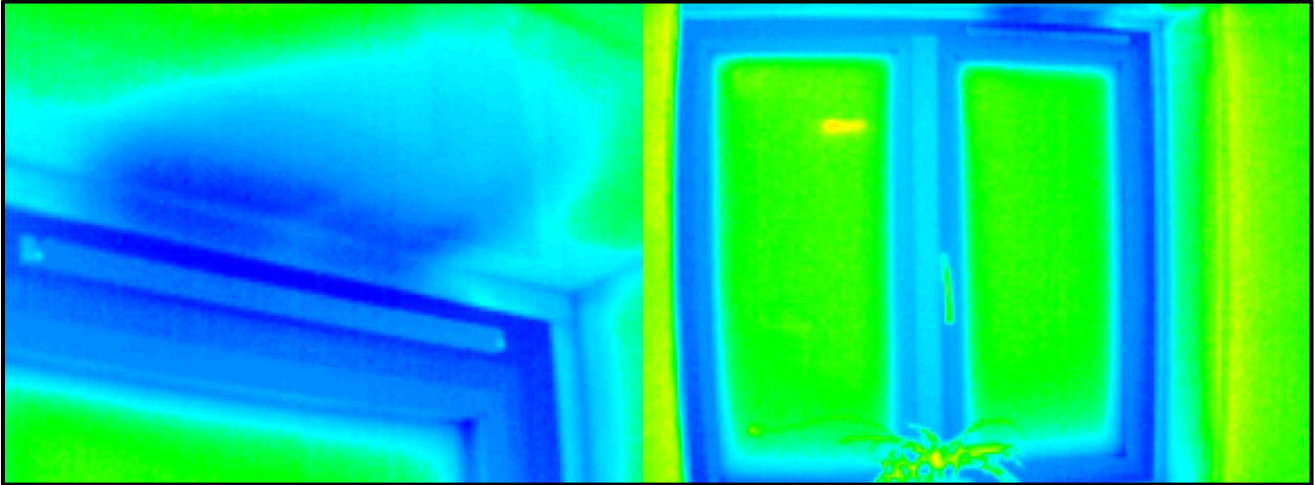
Note; This energy calculation is based on certain parameters being met but is based on real values. There is also potential for more energy to be consumed within the room given that there are additional plug sockets. This calculation is also based on tariff prices per kW/h accurate at 01/11/2018.

A.10 – AS226 Energy Consumption Pie Chart

Energy Consumption AS226

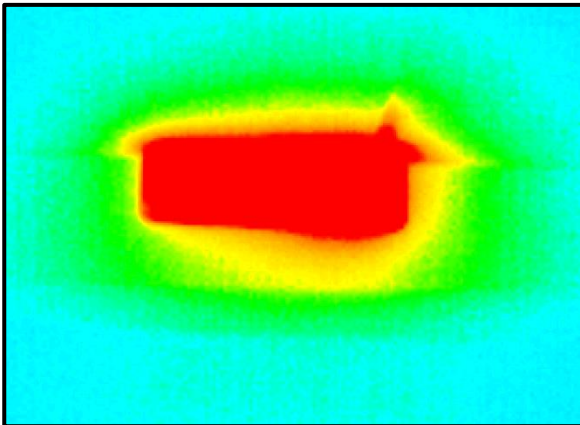


A.11 – AS2K1 Cold Bridging/Condensation



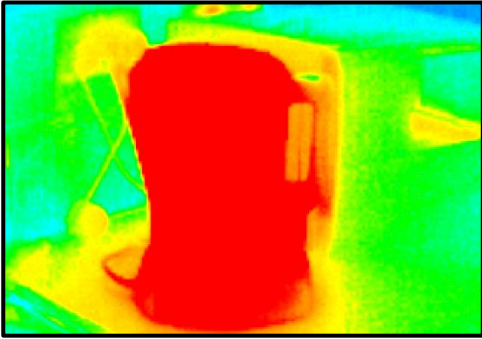
The above images were taken by the thermal-imaging camera in room AS2K1 and clearly show an area just above the window where a cold surface has formed, possibly caused by condensation or cold bridging. It is a warning that the heating, structural insulation or ventilation within the envelope may need improving. If not taken care of, black mold could form, untreated black mould can cause allergies and respiratory problems.

A.12 – AS2K1 Fuse Box



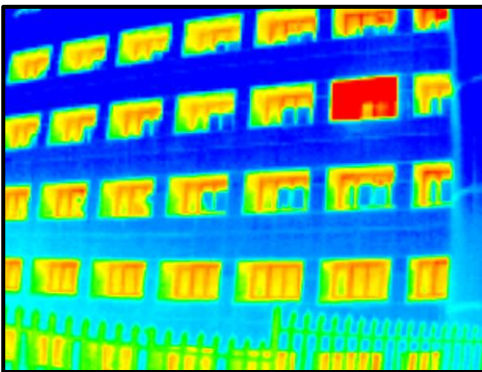
This fuse was off the temperature scale set at 24 degrees and further investigation should be undertaken to understand why. A faulty fuse may need to be changed.

A.13 – AS2K1 Additional Heat Energy



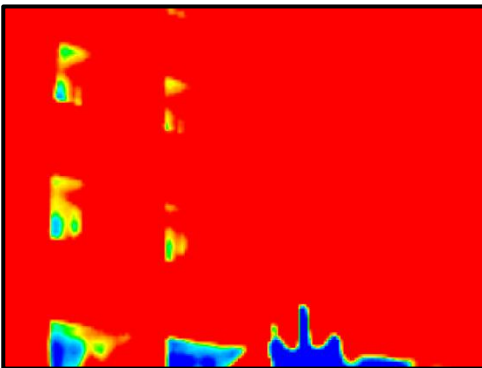
This appliance is a good example of equipment giving un-accounted for energy into the environment. A kettle boils at over 70 degrees and releases most of its energy in condensation and heat into the environment.

A.14 – North-West Façade



This image shows the shaded façade of the building with window areas losing the most energy. You can see an open window letting heat out of the building (Red).

A.15 – South-East Façade



This image shows the direct sunlight hitting the façade causing heat losses not being able to be seen. Although it does show the thermal gains through the windows.