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1.Introduction

In December 2017, a survey taken place in the University of Wales Trinity St. David (UWTSD) has been conducted, precisely at the Lampeter campus. This survey aimed to upgrade the student accommodation and improve the sustainability condition of the building. Lampeter has been graded as Grade II of a listed building. Final year students of the Faculty of Architectural technology course at UWTSD in Swansea campus were assigned to proposed to restore the Lampeter accommodation to make it more sustainable without any modification of the original structure and the overall outside shell of the building. This report ultimate goal is to provide a solution of improving the windows of the building.

2. Findings

2.1. Energy Consumption Worldwide

Energy issues have grown a serious concern in recent decades. Limited energy resources and increasing energy consumption from one side and environmental pollution and waste of resources from the other side have substantially affected the future of human life. With this regard, buildings (residential and commercial) consume approximately 40 percent of the total annual energy in most countries (IEA, 2015) and produce about 26 percent of annual greenhouse gas emissions (EPA, 2013). For instance, about 50 percent of the UK's greenhouse gas emission is attributable to the energy used in buildings (Mithraratne, 2007). In Australia, approximately 25 percent of the total energy is consumed by buildings and households are directly responsible for about one-fifth of greenhouse emissions (Department of Industry, 2013). An average Australian home emits about 7 tonnes of greenhouse gas each year showing that most Australians live in houses that work against the climate not with it (McGee et al., 2008). Around 40 percent of total energy consumption of Australian buildings goes to heating and cooling due to the low thermal performance of the buildings (DWA, 2008). Thermal performance of buildings determines the amount of energy used for heating and cooling of the buildings which profoundly influences energy efficiency. Employing sustainable design principles and effective use of construction materials can play a crucial role in improvement of thermal performance of new and existing buildings (Lyons and Reardon, 2013).

Before the oil crisis in 1973, the energy efficiency of envelop building components was rarely considered as an important factor in building design and construction (CRES, 2000). As a result, significant portion of existing houses, older than 40 years, constructed without considering energy efficiency. Some of these existing buildings are a part of cultural heritage, so importance of preserving them is apparent while considerable numbers of those buildings are ordinary buildings with no cultural heritage value. Demolishing and replacing existing ordinary old buildings with new ones may seem to be a good solution for increasing energy efficiency of the existing buildings. However, the required amount of energy and time for this process would make it absolutely uneconomical. Hence retrofitting those buildings would be the best approach to improve their energy efficiency. Energy retrofitting of existing buildings can be a remedial method to improve energy efficiency and to reduce their environmental impact and footprint.

2.2. Energy Retrofitting Method of Building Envelops

The energy consumption for heating and cooling is normally determined by the quality of the building envelops. Building envelops are the parts of building which separate the habitable areas from exterior environment. Building envelops consist of external walls, external doors, windows, roof, ground and the internal walls that separate conditioned spaces from non-conditioned spaces. The energy loss from the building envelops is the key factor. Heat loss through conduction, convection and radiation from building envelops. Therefore, thermal performance of the building envelops should be improved by using different methods of retrofitting. In this study, the methods of retrofitting have generally been divided into four categories, including energy retrofitting of external walls, roofs and ceilings, floors, and windows.

2.3. Characteristics of Benchmark Building

In this study, an existing building located in Swansea city, the Lapmeter campus has been selected to serve as the study case building for modelling and simulation purposes. Figure 1 illustrates the floor plan of the case study building.

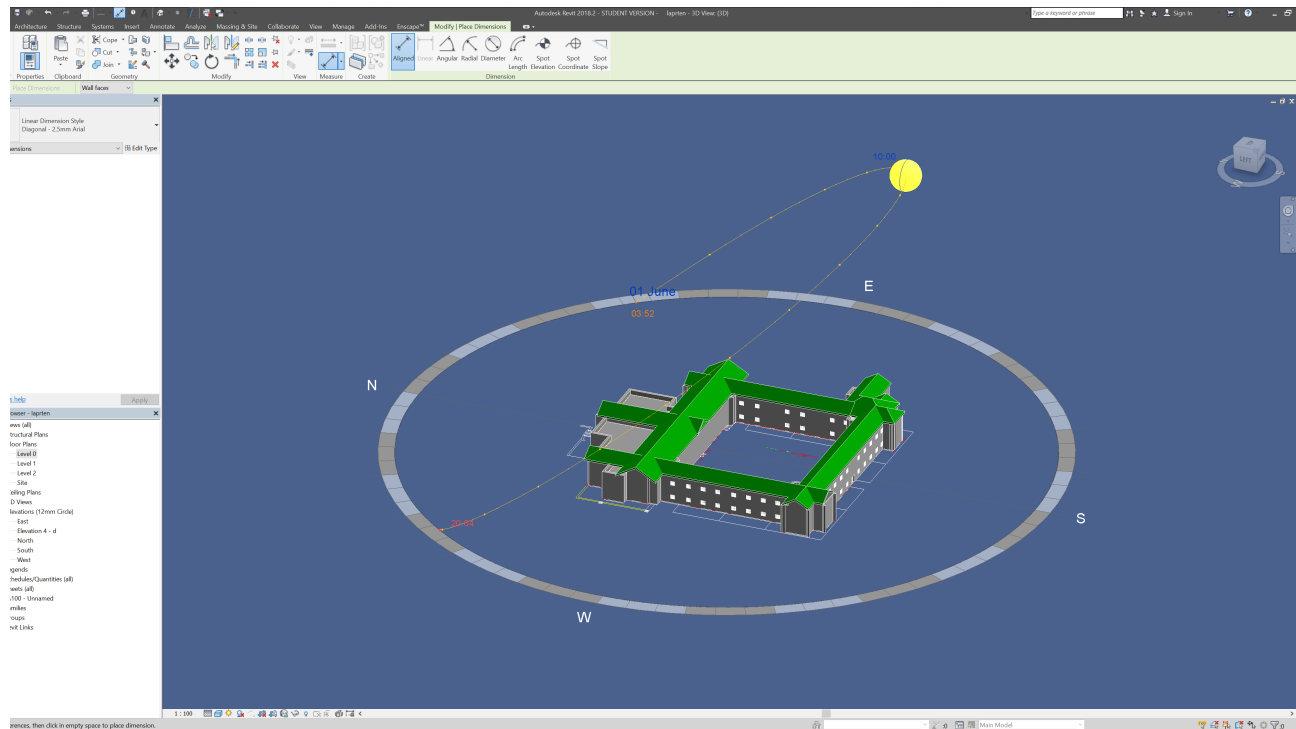


Figure 2. 3-Dimensional model and orientation of Lampeter

2.4. Listed Buildings Classification

A listed building in the United Kingdom is referred to as a registered building in the Statutory List. It is important to note that these are particularly a significant considerations of architectural and historical interest. These buildings are protected against demolition or alteration. With regards to repairing, maintenance or even a small alteration works are needed, prior approval from local planning authorities is highly required. It is considered to be one of its necessity that all listed buildings are to be built by the man's hand with a firm structure and persisting in its own original form. Unless they are religious buildings, they are exempted as it only requires the operating organisation to permit its operations. Interestingly, majority of the listed buildings are well-known across the globe mainly because it has become tourist attractions. Most listed buildings become attractions to human-being as they are typically rich with history, architectural landmarks, bridges, monuments, sculptures, and memoirs of war, landmarks and miles are also listed. Any surviving buildings that are built back in the 1700-1840 are mostly listed. After World War II, all buildings that aged over 30 years old and are exceptionally significant can also be listed.

2.4.1. England and Wales / 3 grades of classification:

Grade I: Buildings with special historical and architectural interest, sometimes of international importance

*Grade II *:* Important buildings, especially architectural styles

Grade II: They are distinct buildings, of National interest and of special interest, in most of them private buildings and residential housing and others.

If the alterations works cannot be proceeded due to issue such as problem getting approval from the local council, it is the responsibility of the owners of these buildings to keep the building in its best conditions. If, somehow these alteration or repair works are made without arrangement with the local council, it is likely that the building's owner can be judged for not complying with all the mandatory processes. In this case, these buildings may have the possibility that its structure changes, if that is what the owner wanted. However, the owner are required to request the removal of his/her building from the listing, although this is not very common in the United Kingdom.

3. Data Collected

These data are collected during the survey conducted on the 12th of December 2017. The survey took place in Lampeter campus UWTSD Swansea by a group of Architectural Technology students from UWTSD Swansea. **(Figure 3)**

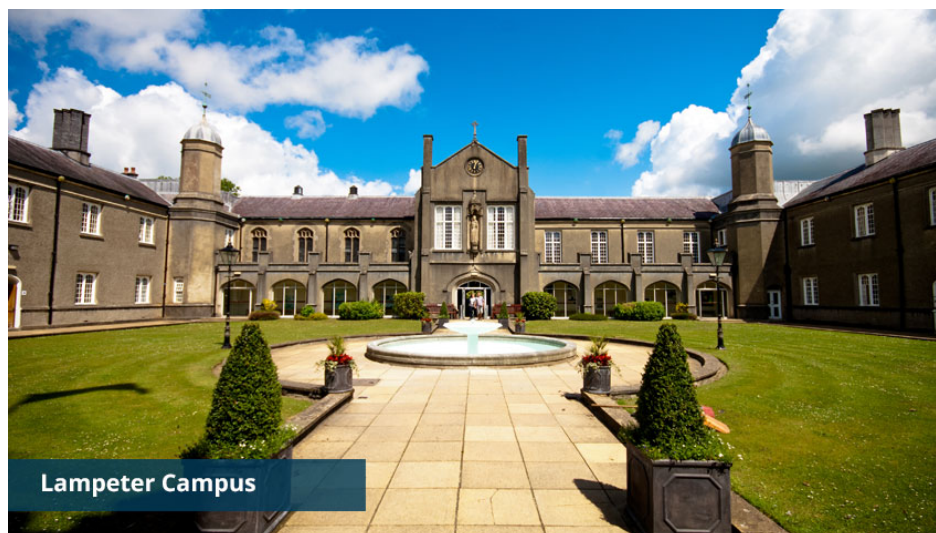


Figure 3. Lampeter Campus

The surveying was made to the listed building on site, and this report is a propose for sustainable windows, conservation and sustainable refurbishment for this building. See Figure 3.

Listed on Grade II: Gates and boundary wall to St. David's University College, Lampeter, Ceredigion (along da SW of station terrace and the E side of College Street).

Listed Date: 10 February 2012

Last Emended: 10 February 2012

Grade: II

Source: Cadw

Source ID: 87646

Building Class: Education

Location: Along th SW of station terrace and the E side of College Street

County: Ceredigion

Town: Lampeter

Community: Lampeter (Llanbedr Pont Steffan)

Built-up Area: Lampeter

Traditional County: Cardiganshire

3.1. History of the Building

The Boundary walls and gateways are possibly contemporary with the original early 19th Century construction of the college but may belong to the later 19th Century phase of college additions. The gates are probably later replacements.

Source: www.britishlistedbuildings.co.uk/wales

4. Discussion of Results

4.1. Report of the Survey

A thorough survey has been conducted to identify all the required work that needs to be done. In this report, restoration of all old windows will be the main focus. See Figure 4. Figure 4 illustrates an example of Lampeter windows to show any possible situation that might come up in the process of restoring and installing the secondary windows. It also shows the thicknesses of profiles that can be used to prevent any alteration of the original design of the building from its external view. The next step was to get access to electronic documents from the local council. The reason for this step is to find out which Grade this building was named in the listings of the local Listed buildings.



Figure 4.
Lampeter Window

Based on the survey, a laser scan has been used as a device to capture water infiltration measurements and the different temperature scales, see Figure 5, Figure 6 and Figure 7. It has been identified that these windows do not require the objectives for a sustainable building, with a single glass panel the energy loss are visible by the colour negative temperature as seen in Figure 5, Figure 6 and Figure 7 as well as the cracks and that have to be improved as the passive design technique suggested. From this research, it can be seen that the south-facing windows have a greater wear and deterioration as they have a better exposure to the sun. This may be one of the reason that leads to a major difference in temperature from day to night. Moreover, the material used tends to break and crack easily. As for the inner courtyard and west-facing side, it shows number of signs of deterioration and this lifts up the needs to improvement. Nevertheless, there is no necessity or requirement for conservation work, which significantly helps in costs reduction.

With regards to the method and restoration process, it is vital to initiate the current windows so that when the interior of the new windows are fixed, the old materials are prepared to get fixed without any risks or anything that would increase the costs. In order to begin the work, all planning works need to be prepared in advance in order adapt Lampeter building's windows efficiently and effectively. A good planning is required to avoid any risks towards the materials and the safety of the worker.

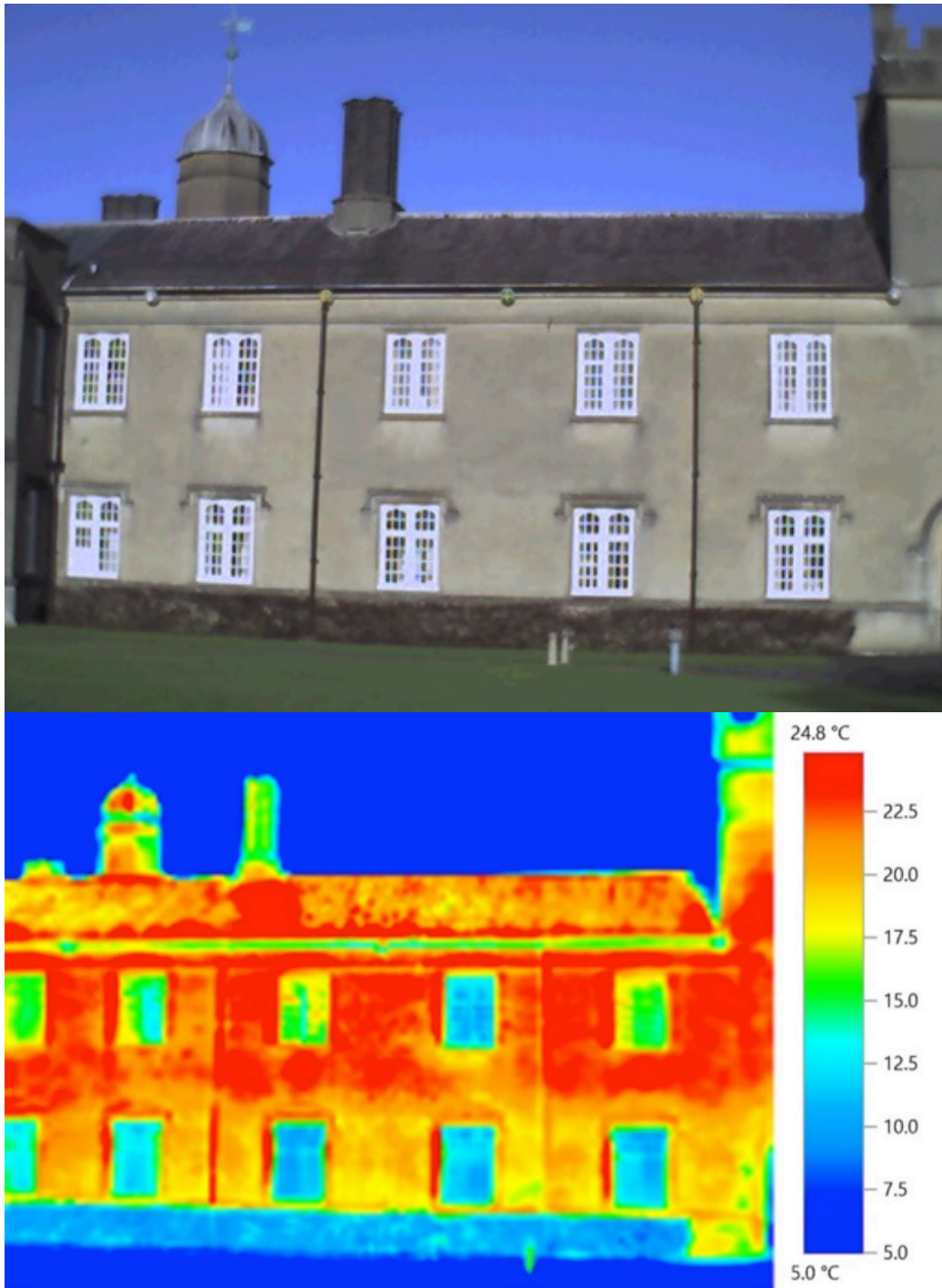


Figure 5. South Facade

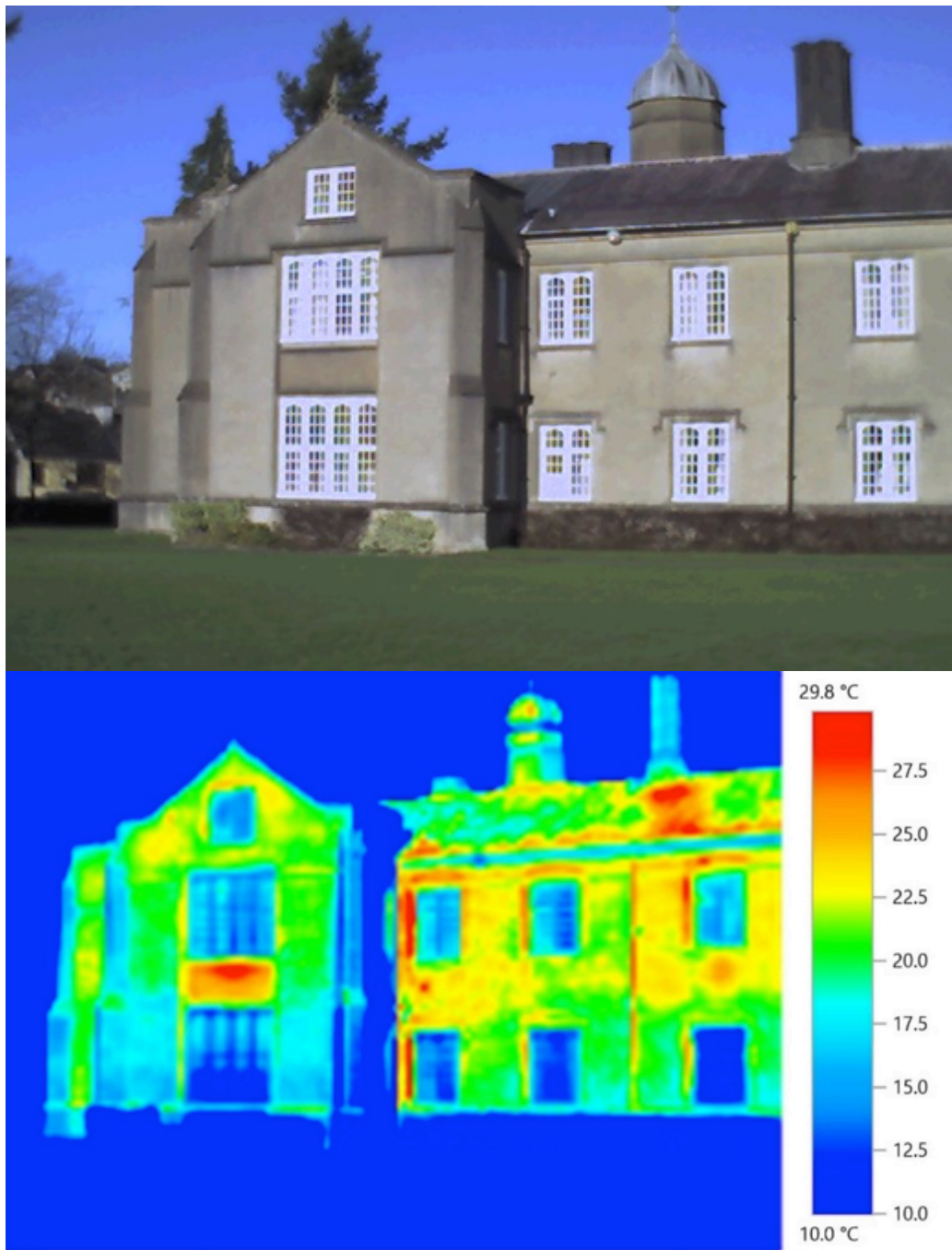


Figure 6. South Left Corner to West Facade

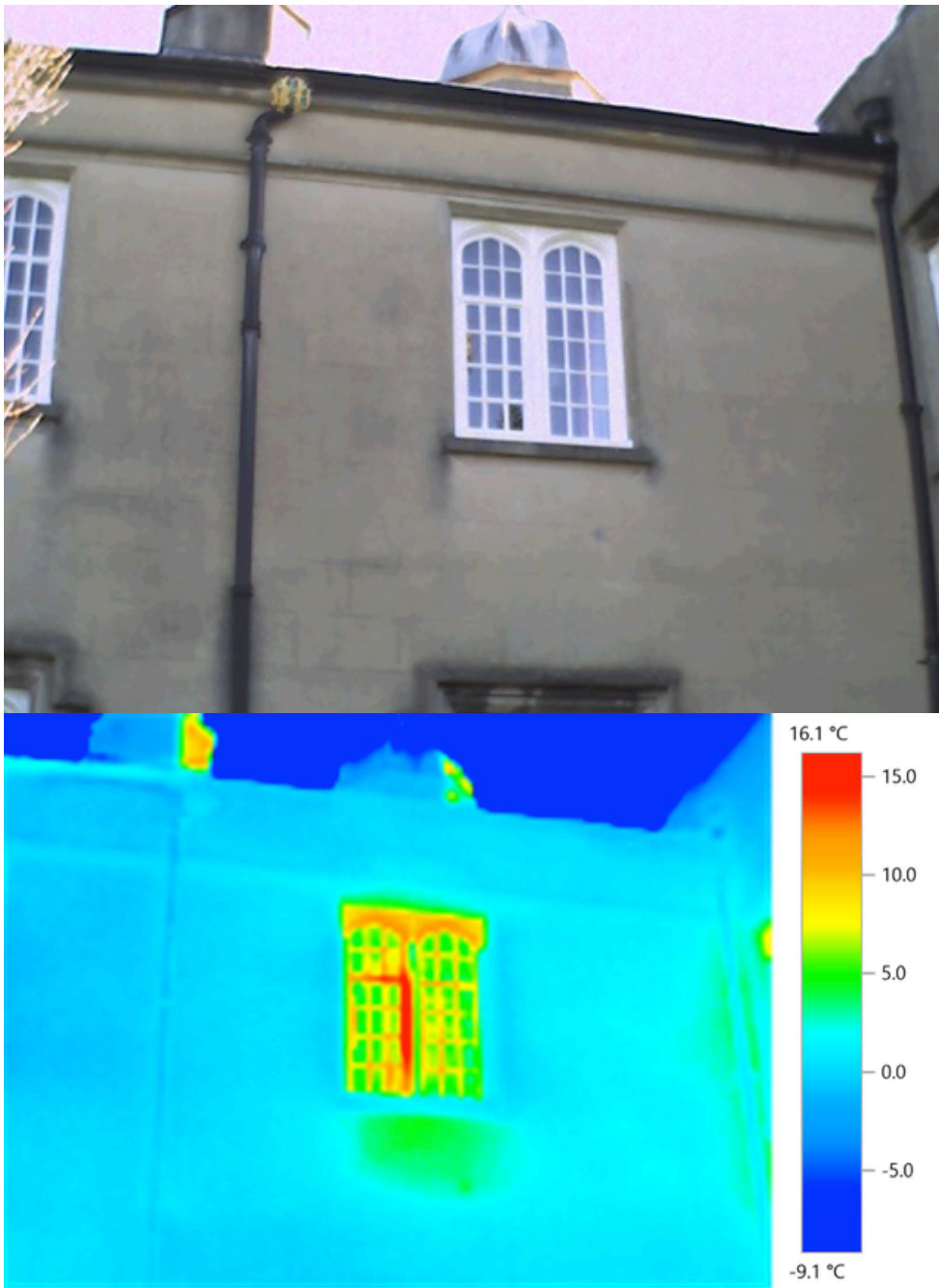


Figure 7. West Facade Level 1 Window

5. Propose

Making the Lampeter campus more energy efficient several factors should be looked at, such as the overall material of the building for example the windows, doors, wall, roof and floor. Examining these parts of the building will lead to better understanding and solutions, furthermore, it could lead to where the building needs to be fixed or replaced if needed. Because the building can't be energy efficient if for example, it has a well-insulated wall but the windows are leaking the hot air out, therefore a combination of solutions such as applying the strategies of passive design, active design or hybrid system will give better efficient results.

With that being said, using the passive design strategy for this case will be more suitable since it will cost less and be subtle for an existing building and one of the key factors of the passive design is to keep the energy losses to a minimum so the building will not consume more energy.

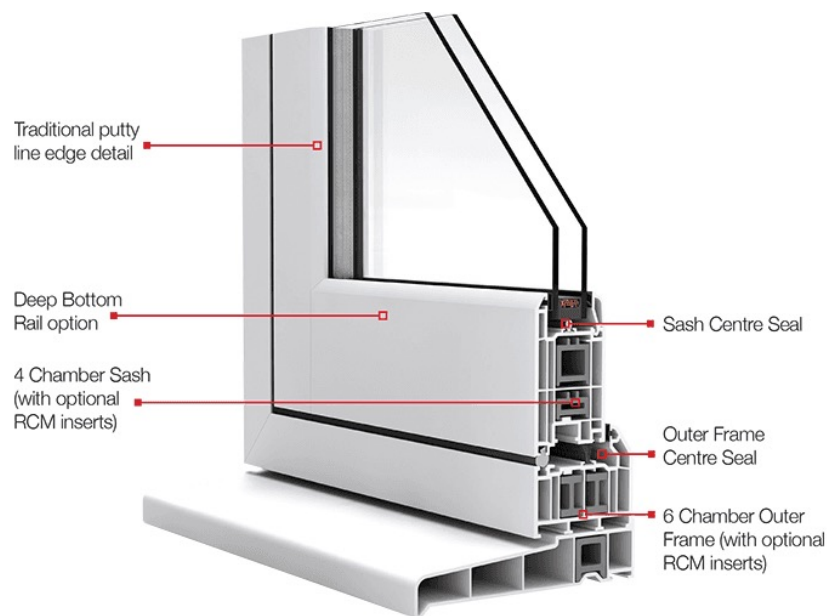


Figure 8. Frame System for Secondary Windows

Looking at the results of the survey done, the windows leak a great deal of ambient energy, therefore it needed to be treated. One of the alternatives is to use internal blinds as it helps to improve the window performance. As a matter of heat loss, heavy and coated curtains may be a good option to reduce the heat loss. Furthermore, the use of double glazing with a double profile will only be effective when the existing frame supports the new features of the new windows. However, in the case of windows in the Lampeter building, it is impossible to eliminate the original windows to replace them with a new one. In this case, another option is to propose a secondary glazing and the placement of an independent UPVC frame as double glazing has the capability to provide the preferred function in a sustainable way. See Figure 8 and Figure 8.1.

The internal double glazed window with fixing the shoulders and window sill, offers the exact insulation values, energy losses reduction, lower the noise and dust entry, assuring the equivalent current light input across the old window. The window's design should be circumspect and projected together with outlining that it cannot be viewed from the outside of the old window to ensure that the original design or the building will not be effected. In addition, supplementary security procedure can be added in a reasonable way in existing windows. Not to forget, the new secondary window also comes with additional safety procedures.

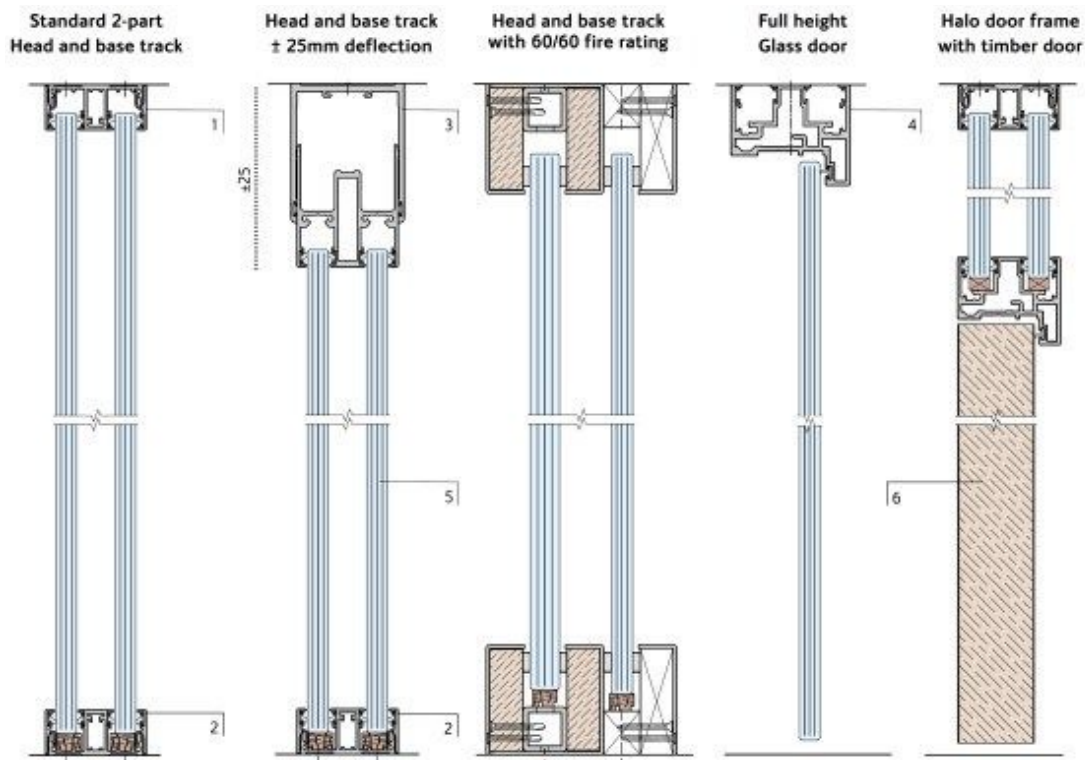


Figure 8.1. Frame System for Secondary Windows

Local: Windows Company at
Lampeter - J & P Home
Improvements

*Double-Glazing Installer in
Lampeter, Wales*

Address: Unit 1-5, Lampeter
Industrial Estate, Tregaron Rd,
Lampeter SA48 8LT

6. Conclusion

As time goes by it become more difficult to maintain historical building such as Lampeter campus, because of the use of better and newer material as well as new more advance technics that for example benefits the the building to maintain its heat as mentioned above.

For Lampeter campus's window, wood frame are easy to replace, However in our case those replacement have to be carefully put as the wooden frame and iron windows tend to get damaged over time by corrosion and need to be dealt with with it carefully because the iron spike are what keeping the windows sticking to that wall and the might effect the surrounded wall, is been mention earlier maintenance are need for those type of building, Therefore regular inspection should be in place to detect the causes may accrue to the building and preventing it form causing and permanent damage and therefore replacing the original parts of the building wont be needed. In most cases, humidity are the reason for causing the damage, but most of the material such as copper, stone, glass and wood can be recycled, for instead, glass can be reused, there metal material can be melted and used as a new material. And luckily, most historical building build with such material.

As this report aim to provide a sustainable solution for retrofitting, The wood beam frame of the widows is one of the best solution to repair the damaged windows. Important factory should be in mind to preventing the widows of a damage over time is the tightness. also, choosing suitable choice of windows frame paint can make the windows water proof to some degree and ultraviolet attacks. As the sun hitting the south facade the most, its windows needs more maintenance, repair and the use of unsuitable material used before can show deterioration.

As the windows on the south facade got exposed to the sun light more and got significant difference in temperature at day and night, so the metal tend to show more sign of wear than the rest of the buildings facade but the also the west and in the middle garden side wall shows some deterioration and needs to be dealt with, however it doesn't need as much maintenance as the south facade.

As mentioned above, to decrease the thermal losses of the building the building should have a well insulated envelope, such as roof, walls and floor. Along with, widows and film glass on them and widows moisture control.

7. Reference

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8. Appendix

Heat map of external wall of Lampeter
Building, UWTSD.