

BUILDING SERVICES AND ENERGY AUDIT

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Module: Services & Energy Performance in Buildings
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1.0 - Introduction

To ensure efficient and cost effective management of facilities, it is crucial to carry out energy audits, organise the maintenance of building services and assessing schedules of plant. This allows the facilities management team to understand the energy use within a building, and how to assess where to potentially save money and decrease energy usage. Within this report, the Author will present field research carried out at Cardiff University Business School, discussing the points mentioned above. Field and desk research will be carried out, utilising the case study building to recommend potential monetary gains and exploring effective building management.

2.0 - CIBSE

In order to follow rules, regulations and legislation, the Chartered Institution of Building Services Engineers (CIBSE) guide provides technical guidance on building services engineering. An example of this would be "Guide M: Maintenance engineering and management" (CIBSE, 2014). *"This document is intended to bring maintenance into a sharper focus by helping building and property operators become more aware of their responsibilities and duties", "It will also help services designers to appreciate their role in providing installations that are safe, economic to maintain and operate, and capable of giving satisfactory performance over their full lifespan."* (CIBSE, 2014).

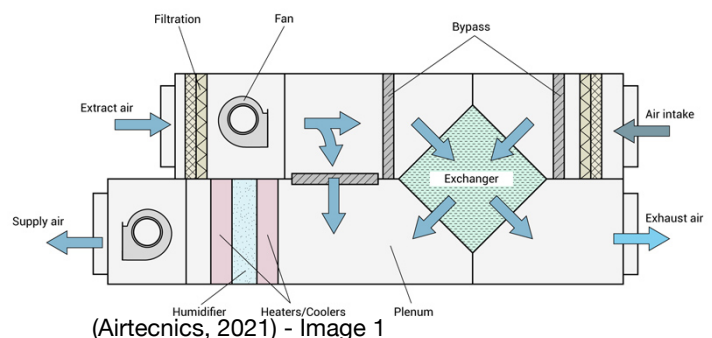
The CIBSE guide will assist the facility team at Cardiff University Business School to undertake required maintenance of the building, for example *"CIBSE Guide M, Appendix 12.A1: indicative economic life expectancy"* (CIBSE, 2014). In particular, condition surveying of the plant, completing maintenance registers and life-cycle planning. CIBSE Guide M also refers to maintenance policies, and the British Standard 'BS ISO 55000 2014: Asset Management: Overview, Principles and Terminology (BSI, 2014a)', to document asset management plan, *"The maintenance policy can be considered as the client's plan for o&m to provide the necessary environment for the occupants within the constraints of the owner's objectives and of legal requirements. At the same time, the policy provides the framework within which the maintenance manager can operate"* (CIBSE, 2014).

2.1 - Cardiff University Business School

Cardiff University Business School, located in Cathays, Cardiff, opened in 2014. The construction of the facility costed £13.5 million and *"provides a working and community space for our full-time students and professionals attending short-courses", "The centre offers two marquee lecture theatres (with lecture capture facilities), 12 flexible and reconfigurable seminar/teaching rooms, two postgraduate common rooms, the fully-equipped and self-contained executive education suite and our flagship trading room"* (Cardiff University, 2020).

2.2 - Delivery of Engineering Services

Within the university there are many services which are required to create a comfortable, efficient and sustainable environment for its users. This would include mechanical ventilation. *"At every moment, demand controlled ventilation offers an optimization of heating consumption and indoor air quality, on a fully automated basis"* (Aereco, 2021). The ventilation will ensure clean air, decrease moisture in the building, decrease odours and pollutants which could build up within the university building, especially when at full capacity; increasing the heat and moisture from your person. The ventilation should be circulated from the vents within the floor scattered throughout the facility,



as seen in 'Image 2' below, which often created drafts within the facility and made the rooms feel dry and cold. This will be further discussed in section 4.0- Energy Audit.

This ventilation would typically also be driven by an air handling unit (AHU) which supplies and extracts air from inside the building, this can be seen in 'Image 3'. The air handling unit is often modular as seen below, which purify or renew the indoor air in the facility. On this occasion in the university, the AHU was located in a plant room, however these can also be located on the roof of a building. Within 'Image 1', we can also see what the AHU consists of and how the air is "recycled".



(Bethan Stroud, 2021) - Image 2



(Bethan Stroud, 2021) - Image 3

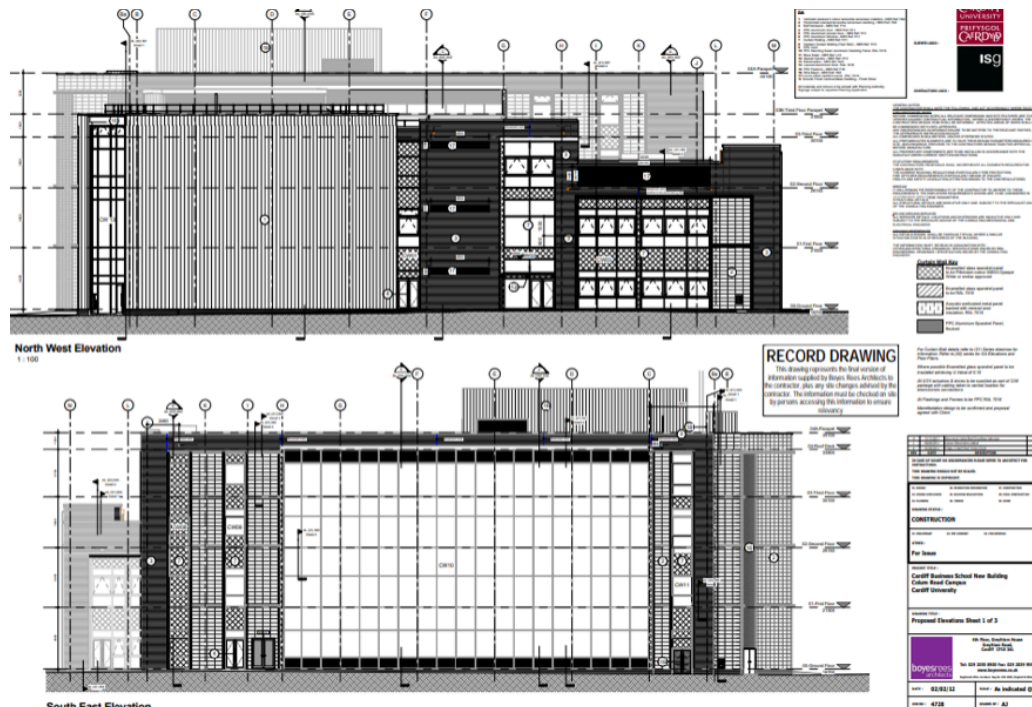
At the university facility, another item of plant which was identified was the solar panels. *"Solar panels work by absorbing sunlight with photovoltaic (PV) cells, usually after being placed on the roof"* (Look After My Bills, 2021), in this instance was placed on the roof of the second floor above the building's atrium, creating a sun trap; ensuring the correct orientation and angle to increase solar gains. *"The panels convert this sunlight into direct current (DC) energy which travels inside the house to an inverter, which in turn converts it to alternating current (AC) energy, which then flows through the home's electrical panel powering any appliances with electricity"* (Look After My Bills, 2021). This will decrease electricity bills for the university, however will increase maintenance to look after the panels, e.g. cleaning the panels. This bioclimatic architecture within the building also increases the sustainability and lowering energy consumption.

Another energy saving and sustainable feature of the university is the glass facade. The darkened glass feature ensures solar gains and natural light throughout the building, as seen in 'Image 4'. Features such as glass facades also decrease energy usage, resulting in lower



(Bethan Stroud, 2021) - Image 4

carbon emissions, and lower costs. Solar glass works in “non-optimal conditions, in lower light and higher temperatures. This means a longer day of solar gain compared to ‘traditional’ panels.” (Reenage, 2016). The glass also can act as an insulator in the winter months, as well as reducing heat gain in the peak summer months, however it is unlikely that the building would be heavily used during this time. Within ‘Image-5’, the glass solar facade is shown in the as built elevations by ISG.



(ISG, 2012) - Image 5

2.3 - BSRIA

As well as the CIBSE guides, Building Services Research and Information Association (BSRIA) also supplies guides for maintenance, for example “Handover Information and O&M Manuals (BG79/2020)” (BSRIA, 2020). “This guide covers the various documentation delivered and activities carried out at handover of a building, with particular focus on operating and maintenance (O&M) manuals. The O&M manual is the key part of the information needed during operation of a building, and as such is discussed here in detail. Historically, having all the desired information available on completion of a construction project has often been problematic, but by following a clear process of identification and route planning, the operators will be in a much better shape from handover.” (BSRIA, 2020).

3.0 - Maintenance

To ensure a building is running smoothly, efficiently and correctly, maintenance of services, appliances and equipment must be carried out. This will also ensure comfort for the buildings users and managing unwanted wear and tear to engineering services. This can include “the inspection, repair, and maintenance of building systems including HVAC, electrical, and water”, “washing windows and glass doors” and replacing lighting. “Educational facilities have many different buildings that contain capital assets like research equipment. Equipment maintenance is responsible for maintaining the condition of these assets while the facility management office is responsible for managing the complete asset lifecycle. Light and ballast replacements, HVAC inspections, and emergency repairs for flooding and leaks are also part of the equipment maintenance.” (Upkeep, 2021). To assist with maintenance decisions, CIBSE Guide M:

Maintenance engineering and management can act as a guide for facilities management. In the case study of Cardiff University Business School, an operations and maintenance plan, or schedule, should be implemented to ensure effective and reliable maintenance is carried out to look after the facilities and equipment of the building. This could be completed by outsourcing the maintenance works, or carrying it out in-house.

3.1 - In-House Maintenance

In-house maintenance is summed up as *“an activity performed within the same business, using the company’s assets and employees to perform the necessary work”* (Hayes, 2021). Carrying out maintenance in-house requires a fully trained estates team who understand the buildings processes and detail on how it best works to ensure the facility is well maintained. As Hayes highlights, *“At times, internal employees may have a better understanding of how the business functions overall, providing them with insights into how certain activities should be handled, allowing them to function with the business’s core vision at the forefront of the decision-making process.”* (Hayes, 2021).

An advantage of in-house maintenance is that the team would be working full time at the building, resulting in potentially higher knowledge and understanding of the facilities. The team should be able to track and plan, ensuring required tasks are completed on time. This would also include tasks such as basic cleaning, changing lights, cleaning filters, grounds maintenance, exterior cleaning, as well as cleaning the glass facade on the Cardiff University Business School. However, a disadvantage would be that increased costs of in-house maintenance. This would be due to the yearly salaries of the estates team, training costs for new equipment, technologies and legislation, cleaning equipment and other purchasing items e.g. tools.

One argument of in-house maintenance is that it ensures more control of the building and its facilities, compared to out-sourced maintenance. According to the National Society of Automation, *“Outsourcing the maintenance function may be cost-effective, but there are definite restrictions to working with contractors. This includes obstacles such as the client company’s inability to directly manage, set task priorities, and instruct the workforce. The geographic location of the facility may mean that contracted personnel with specialized skills may be limited or unavailable. This may require hiring in house talent unless an outside contractor has a strategy to be responsive to this need”* (Automation, 2016). In terms of control and knowledge of the facility, in-house employees will have more years of service within the estates team, compared to staff working for a contractor. The employees will have an advantage of knowing the establishments values, being a university in this case, respecting that the end user, being students and staff, require comfortable learning and working conditions which increases efficiency and learning. *“The outsourced workers may not possess as much allegiance to the company”* (Automation, 2016).

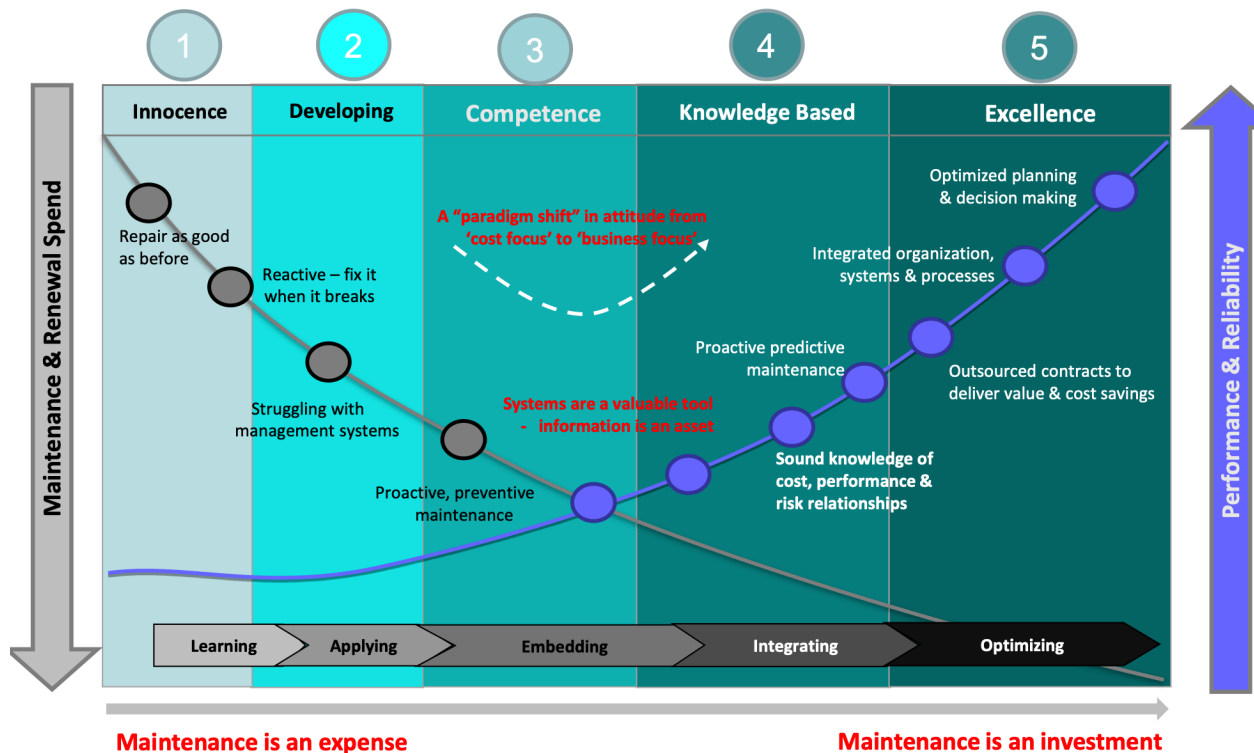
A likely disadvantage of in-house maintenance is that it is not likely that the facilities management team would be knowledgeable and trained in IT and FM. This will limit the work the facilities team could carry out, especially keeping up to date with new technologies. This is discussed by TPG, maintenance and refurbishment specialists; *“there is unlikely to be both the IT and FM expertise within your business for the software to be developed enough to meet specific industry requirements that constantly change and need updating to ensure compliance is achieved.”* (TPG, 2017). On these occasions, an out-sourced maintenance specialist, or team, would need to be hired to carry out the works the facilities management team are unable or equipped to do.

3.2 - Out-Sourced Maintenance

Out-sourced maintenance is the hiring or employing of an external contractor to complete the required maintenance works. These can be specialists or general cleaners. As stated by Servi-Tek, an facilities management provider, *“Hiring a professional team delivers numerous benefits. For starters, your vendor will help lighten your workload and work within your budget parameters”, “Most facility maintenance companies today offer a comprehensive package to address all your needs”* (Servi-Tek, 2020). Although this is a business, which would result in bias, these are benefits of out-sourcing. Hiring an external contractor can potentially save costs on annual salaries for an estates team. However, the University would

require a facilities manager to identify issues, areas of maintenance and work in order to instruct works to be completed.

Another advantage of out-sourcing maintenance is that the contractor can provide all equipment, tools and materials rather than the University team purchasing these items. The out-sourced maintenance team will be fully trained on how to use the differing technologies, *“The same holds true for specialized tools and equipment, in that the contractor would be required to supply the tools and equipment to perform the work required”* (Manufacturing, 2014). This will also result in the facilities management team not having to replace, as well as maintain, the tools and equipment assets, resulting in reduced costs. Below is a diagram published by RICS, illustrating the advantage which out-sourcing has on a maintenance investment, showing it’s increased reliability, cost savings and optimised planning.



(RICS, 2019)

On the other hand, a disadvantage of out-sourcing maintenance is the turnaround time. Where this would not so much be an issue during summer break and Christmas at the university due to the lower occupancy levels, as well as times through covid there would not be as much of a demand for the works to be completed immediately; by out-sourcing there can often be a delay in the works being completed and get the contractors to the university. *“When dealing with specialty contracts such as PLC’s, refrigeration and complex compressors, a response time to problems may be handled more rapidly in-house when compared with a phone call to an offsite vendor. The host company must balance the needs of the site against the decision to outsource this work and negotiate an acceptable response time, such as 24 or 72 hours”* (Manufacturing, 2014). However, this would not be as big of an issue as the case study building wouldn’t be losing production time for example, but would be difficult to move classrooms if at full capacity.

3.3 - Recommended Approach for the Case Study Building

In the case of Cardiff University Business School, the Author believes that the best solution would be a hybrid of in-house maintenance and out-sourced maintenance. This will result in a monetary saving on staff costs by having a smaller estates team, maintaining small and basic

elements of the building. This team can be run by a facilities manager who is skilled to identify issues which may be more complex, resulting in an out-sourced contractor to carry out maintenance or works. This will also allow the out-sourced contractor to use more highly skilled, or specialist trades to carry out the work who will have a more advanced and niche knowledge on their trade. To assist with this, the full time estates team will be able to know more about the building, rather than being completely out-sourced, and can ensure a plan or schedule is in place to efficiently carry out upcoming maintenance, or ready to hire externally in time to avoid the possible delayed turnaround time. The team will also understand the universities expectations and what is required to ensure the end user is not disturbed during term times, unless completely necessary.

4.0 - Energy Audit

An Energy Audit is an inspection to identify where and if energy is possibly wasted or highly used, as well as by what equipment, in order to minimise expenditure, energy consumption and increase efficiency within a building. By carrying out the Energy Audit's and discovering a facilities inefficiencies, the facilities managers can also reduce environmental emissions and the building's carbon footprint. *"Identifying areas where energy is being wasted can save money in the long term, and the results of your audit will suggest ways where you can reduce your energy consumption to cut costs and reduce your carbon footprint. An effective audit is all-encompassing and takes everything into account, inspecting both the building's interior, exterior, its fixtures and equipment, to determine how these systems interact with one another"* (Gazprom Energy, 2021). Within the audit it is important to identify the inefficient areas across the plant and equipment; highlighting what areas need to be improved. *"A structured, systematic walkaround on your premises serves to identify energy saving opportunities. As we mentioned, a successful audit should be as thorough as possible, so a clear framework for the physical investigation is key."* (Gazprom Energy, 2021). Once the audit has been carried out, the savings must be quantified, assessed and implemented. This can be completed by calculating and monitoring energy savings within the buildings data feedback. This can be in values of carbon or money for the end reader. However, it is important to calculate the payback period for your implementations or investments, and whether the costs are simply worth it for the business.

4.1 - Performance and Evaluation

Energy Audit	CARBS
Basic House-keeping survey	- No previous audits available - BMS system utilised - Desk-top fans present - Heaters under tables - Staff blankets, scarfs, jackets present - signs of uncomfortable climate in office - Dry air throughout building - Drafts throughout building
Appliances and Equipment	- Appliances mostly on (not in use) - High charges for utilities - Equipment all on standby - Phones on throughout building (1KW combined) - Automated lights throughout - LED lighting
Thermal	- HVAC system (AHU) - Solar panels - Solar glass facade - Ventilation - floor - Small window openings

Energy Audit	CARBS
Water	- Push taps (some jamming) - Signs of leaks (water stains in walls) - DHW - Pumps - sprinkler - Boiler - thermal protected - jackets
Sustainable features	- beehives - Water harvesting - Solar panels - Solar glass

A result from the energy audit is that the university building has a well-working facility, maintained to a good level and with an organised asset plan. However, with observations within the building, the presence of desk fans, heaters and abundance of blankets suggest uncomfortable conditions within the office spaces. *“Most offices rely on air conditioning units or radiators which get the job done but consume a lot of power. Unfortunately, these methods are inherently inefficient as they heat the air around the office which is going to be wasted as people enter and leave their offices.”* (Healthy Heat, 2017). It is known that you cannot please everyone in a working environment, however by visual observation the majority of working areas had a cooling or thermal source. To solve this, seats can be moved around the office as many chairs were sat directly above the ventilation fans or by the windows.

It was noticed that during the appliances, equipment, as well as the office phones were all left on. Although this is a minor aspect of cost and energy saving, it is good house keeping which adds up. In addition to this, it is also an energy saving attitude to establish throughout the users.

4.2 - Investment Recommendations

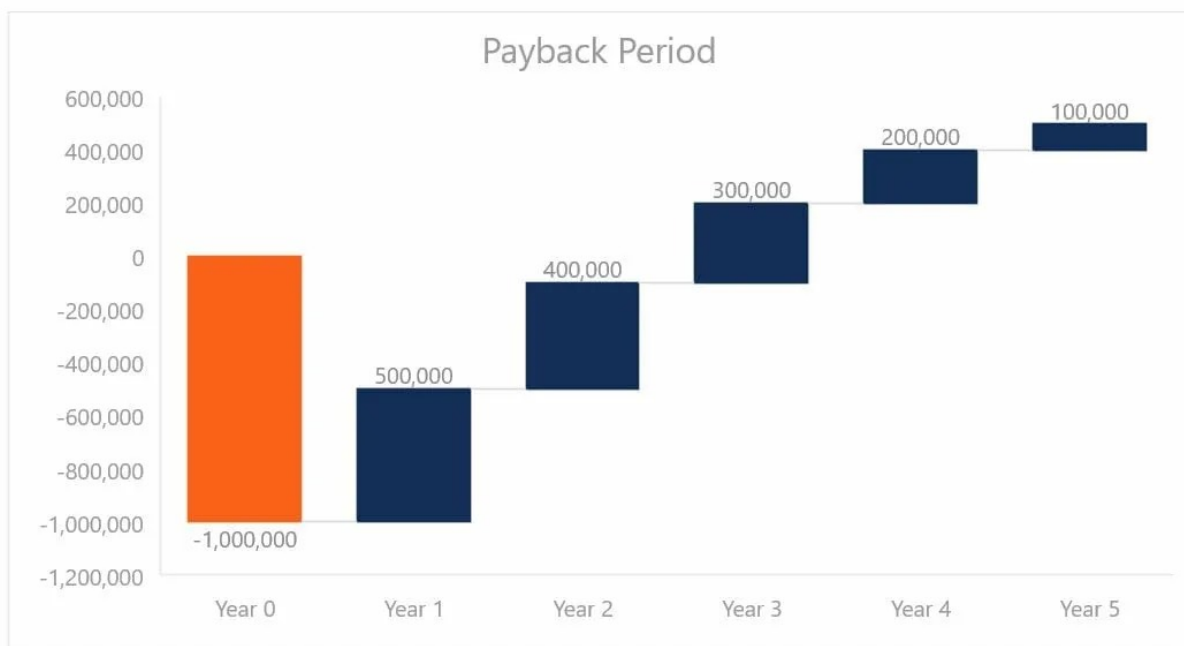
There are a few recommendations which can be made to improve the facilities energy usage and lower costs. These can be divided by ‘No/Minimum Cost’, ‘Medium Cost’ and ‘High Cost’.

	Description
No / Minimum Cost	- Inform users - Good house keeping - Shut down unused appliances / equipment
Medium Cost	- Upgrade low lighting - desk lights - Upgrade taps/toilets - sensor
High Cost	- Ventilation system (HVAC)

It would be recommended that the Cardiff University Business School implements a better basic house-keeping and awareness throughout its users and staff. This is a zero or very low cost to the university to carry out, which will result in savings in the long run. This can be done by placing posters around the university reminding users to turn off, place on stand-by, not use equipment they don't really need and saving water.

Medium costs would include upgrading to desk lighting. This would reduce energy and costs by not needing to use ceiling lighting, unnecessarily lighting up a whole room. By using desk lighting it would ensure specific areas are only used, which would be especially useful during out of term times when the university is quieter, during daylight hours when natural light can be more utilised, as well as the result from Covid-19 where the physical classrooms may not be as highly utilised as previously. In addition to this, upgrades taps and toilets could decrease the waste of water. By installing sensors on taps and automated flush can avoid jamming on the push taps and over-flushing which was identified during the energy audit.

A high cost item would be to upgrade the HVAC system at the facility. Due to observations of cold and draughty rooms, it would be in the interest to upgrade the system, ensure temperature controls are available in all used areas, shutting off the unused and making the ability to divide usage. This would also result in less energy use and decreased costs. Of course, due to the large expenditure, it would be important to carry out value engineering and calculating the payback period for all the investments. *“The Payback Period shows how long it takes for a business to recoup an investment. This type of analysis allows firms to compare alternative investment opportunities and decide on a project that returns its investment in the shortest time, if that criteria is important to them.”* (Corporate Finance Institute, 2021). In addition to this, the maintenance costs and total life-cycle would need to be taken in to account to ensure the university can afford to maintain the newer technologies. ‘Image 6’ illustrates an example of a positive payback period.



(CFI, 2021) - Image 6

5.0 - Conclusion

To conclude, the report has identified methods of how the building engineering services are delivered within the Cardiff University Business School. This is seen through the briefly identified solar PV, solar glass and AHU. The building is seen to have features of bioclimatic architecture, increasing the buildings efficiency and resulting in cost and carbon savings. Guided by BSRIA and CIBSE, the building is well maintained to ensure the end user, being students, lecturers and office staff can carry out their day to day roles productively without interruption from the facility not working as it should. This being said, there is evidence of thermal discomfort throughout the building which needs to be improved.

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