Commercial Viability of Green Retrofits for Small Businesses in Buckinghamshire

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I further declare that this dissertation has not been accepted in part or in full for any other degree, nor is it being submitted currently for any other degree.

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Abstract

Taking inspiration from the trend of sustainable facilities management and current discussions on carbon emissions reduction, this paper looks at cost efficient ways to implement green retrofits in the UK retail environment. Following on from discourse on the history and impact of sustainable facilities management which showed a disparity in adoption of sustainable facilities management practices between larger corporations and smaller businesses', we will look at methods for quantifying the benefits and viability of green retrofits, with a view to prove the commercial viability of green retrofits for smaller businesses. Focusing on two low cost and non-invasive methods to upgrade a building, namely LED lighting and thermal insulation, we will take a portfolio of small to medium businesses in Buckinghamshire with a variety of construction times and methods, and recommend and quantify the benefits of green retrofitting with these two technologies. Overall the study showed investment in LED lighting and thermal insulation significantly reduces the overall kWh usage of small to medium retail businesses. The payback time for implementation of these assets into the portfolio was significantly shorter than the lengths of leases, and the payback in terms of cost reduction due to upgraded lighting and thermal insulation was 2-3 years for both assets across all sites in the portfolio. Overall there is no good reason for a business not to commit to the relatively minimal capital outlay as the payback period is well within the average lease period. In addition to the cost implications which are the primary driving factor behind investment decisions, implementation of LED lighting and thermal insulation significantly reduces the relative CO2 emissions by the businesses in the portfolio, which contributes towards national and global emissions reduction targets.

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Introduction

We live in a time of abject uncertainty regarding the future of the human race. Whether the constant warnings over the state of the planet and its ability to sustain life come to fruition remains to be seen. With governments around the world gradually committing to reduce emissions and take responsibility for waste, some groups take to the streets to make their voices heard, as seen this summer across the UK with extinction rebellion. However the fight to reduce the impact of inexorable human development will not be won on the streets; it will be won in laboratories by scientists discovering new more efficient ways to live, and in the boardrooms of big business deciding to implement sustainable technologies, and with the investment power to do so. For better or worse, we live in a capitalist society, a capitalist society with one primary driver; profit. If an investment into a science lab to develop a new technology which could help save the planet isn't viable the likelihood is it will not gain funding.

That said, we have already made incredible strides to improve our lot, and reduce our consumption of the planet. New methods of energy generation and storage continue to be developed. Take Tesla, the American automobile company, and its subsidiaries. With its solar and battery technology it has started providing energy to remote or disaster struck parts of the world. In the past 12 months, the company has addressed two great cataclysms with its technology; following hurricanes which badly damaged Puerto Rico, destroying its electricity infrastructure, Tesla stepped in to develop over 11000 small scale energy projects, restoring power to the island and reinforcing its electrical grid against future natural events. In Australia, Tesla manged to smash a challenge by the government to implement solar and battery systems to remote areas. In the property industry a lot of emphasis is placed on the green credentials of new buildings. This is only natural given sustainability can be designed into the mechanical and electrical services, and indeed the very fabric of a new building. However grandiose some projects are, they do not always filter down to the smaller scale organisations across the planet.

Although larger corporations have the funding and buy in to invest and develop green technologies, smaller scale organisations are not able to take advantage of such technologies. The sustainability agenda is therefore not accessible to all organisations across the globe; yet for us to make a meaningful stand against climate change and the potential and assumed extinction of our species, we all have to do our part against the climate menace. This body of research is intended to look at the smaller scale of the sustainability agenda. Across the UK, our high streets are filled with charity shops and nail bars, small scale retailers which may not necessarily think to upgrade their shops with energy efficient technologies due to a perceived hurdle in cost. In reality, the cost to upgrade buildings to energy efficient technologies is not as great as people think. The cost to produce and install items such as LED lighting has come down drastically in recent years, and these days ought to be accessible to everyone. When the cost to implement is seen as a capital outlay the numbers can be daunting especially to a small business; however when quantified in terms of cost reduction over a period of time, the reasons in terms of cost and reduction in energy use for carrying out a capital investment retrofit, with minimal impact to trade in the retail sector, may be worthwhile.

Literature Review

Retail portfolio accounts for a significant amount of all commercial property across the world and in the UK. 35% of all commercial property in the UK falls under the retail sector. Of the total £486bn tied up in the sector, a massive £171bn is assigned to retail property. Of this £171bn, the majority of investments are in existing retail units, high streets, shopping centres and out of town outlet malls. Although there is some new build development in the sector, in the 21st Century it tends to accompany other developments, or larger scale construction, such as Croydon's impending whitgift relocation. Margins in the current retail climate are getting slimmer and slimmer due to the impact on the sector of ecommerce; as a result retailers are looking for innovative ways to reduce costs and keep shops open and people in work. Some methods for reducing costs align with the sustainability goals of the world and general populace. For larger retailers, creating a portfolio of cost efficient shops with sustainable technologies, reducing power consumption and the overall carbon footprint, is easy; through use of group buying or procurement processes favourable conditions exist to drive costs down to the point where implementing sustainable technologies is a no-brainer. However, for smaller retailers, is this really an option? When we think of big retailers, we tend to think of shopping centres these days; massive developments designed from the ground up to conserve and save energy through efficient construction methods and efficient, well designed services. Smaller retailers tend to occupy units which are increasingly decreasing in value and environmental credibility. As we so often are told, the British high street Is dying, and the nail bars and charity shops which occupy the old units formerly occupied by the likes of Kwik Save do not necessarily have sustainability goals at the fore of their operation. Although simple steps to retrofit buildings to make them more sustainable exist they are not always taken up in the UK retail sector. For many retailers the tendency is to take a unit on but not make any or many alterations to the fabric or services of the building, keeping whatever the previous tenant had in-situ. This position and situation has influenced my research goal, as I'd like to investigate just how viable retrofitting a couple of simple technologies, namely LED lighting, insulation and double glazing, into small to medium retail units would be on the British high street. I hypothesize that the cost to implement such technologies into small to medium retail units will have a short payback period and therefore be worthwhile to implement. As part of my literature review I will look at the concepts of sustainability, the role of the facilities manager in delivery on sustainable development goals, and methods and tactics for upgrading and retrofitting sustainable technology into buildings, and finally what measures we can use for identifying the green retrofitabillity of a given building.

Sustainability is an essential trend in 21st Century facilities management. Global warming is perceived as a near threat to the extinction of humanity, largely due to increased greenhouse gas emissions caused by human activity. The Paris Agreement is the worlds first comprehensive climate agreement, signed by 195 countries, attempting to limit overall levels of global warming to below 2 degrees above pre-industrial levels, and to limit the increase to 1.5 degrees centigrade. The agreement also aims to increase the global economy's ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production. In addition, the accord aims to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development.

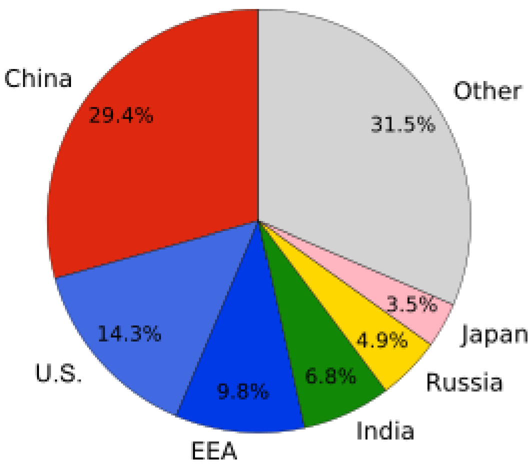

Figure 1: Breakdown of CO2 emissions by jurisdiction

The aims of the agreement will be achieved through a group of targets called the 20/20/20 targets, namely; reduction of carbon dioxide emissions by 20%, increase in renewable energy's market share by 20%, and a 20% increase in energy efficiency. To achieve these targets each signatory country has an individually determined contribution to the overall target; Nationally Determined Contribution's (NDC's). There is no overarching guiding force to what the contribution should be, other than "ambitious" and "representing a progression over time" with "a view to achieving the purpose of the agreement". With this in mind countries around the world, including the UK, have begun setting or improving on carbon reduction targets. In the UK, the Committee on Climate Change sets a carbon budget for the UK every 5 years (beginning in 2008) and measures output in relation to 1990 levels. In 2018, UK emissions were 44% below 1990 levels, and we are set to outperform the current budgeted period ending in 2022. This reduction is largely driven by changes in the way we produce energy. Government published statistics on energy trends published by the Department of Business, Energy and Industrial Strategy show a reduction in our dependence on fossil fuels year on year since 2010.

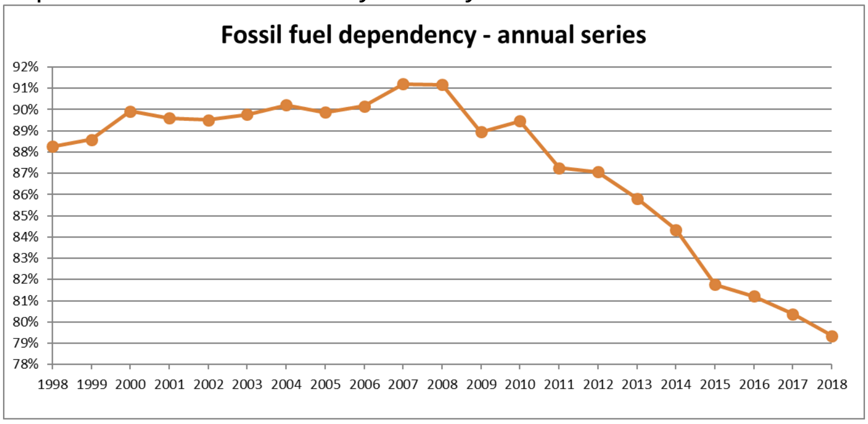

Figure 2: Department of Business, Energy and Industrial Strategy supply and use of fuels statistics 2019

The current target for 2050 for a 100% reduction in greenhouse gas emissions to 1990 levels is ambitious, and rapid and massive changes in the way we live is required in order to meet this target. As businesses increasingly adopt positions of corporate social responsibility (CSR) either by choice or current or impending legislation, the purpose of the facilities manager becomes ever more important, playing a key role in the execution of the objectives instructed by a company's sustainability policy (Tucker, 2013). As reported by the IMFA in 2007, an emerging key competency for Facilities Managers to develop was a knowledge and understanding of trends in sustainability (Wood, 2006). The nature of Facilities Management has evolved over the years. In the 1970's and 80's the discipline developed management functions we take for granted today; outsourced services, quality management etc. In the 1990's and 2000's Facilities Management became increasingly integrated into the overall structure of businesses, taking on a strategic and transformational role as opposed to purely operational or tactical (Alexander, 2009).

The impact of climate change has become a pressing issue in recent years. Governments have implemented statutory guidance or requirements to reduce carbon emissions, which affect the built environment; for example EU legislation to reduce the availability of HFC's, which are used in HVAC systems among other technologies. As society has acknowledged the impact humanity is having on the planet, and awareness has been raised in the general populace, there is increasing pressure on corporations and organisations to define, adopt and adhere to their moral position in dealings with the environment, not only through the direct actions and operations of the company but through their support services and supply chains as well (Appleby, 2009). As far back as 2002, the Global Alliance for Building Sustainably published a charter outlining the impact the built environment has on climate change, and acknowledged it is necessary for action to be taken to reduce the impact the built environment has on the global environment (Shah, 2007).

With this in mind, the Facilities Management sector has evolved to take on a sense of ownership of sustainable business practices. As noted by Elmualim in 2012, the top three drivers for modern Facilities Management are energy management, waste management, and reduction of the carbon footprint. Good energy management practices include the adoption of energy saving technologies, such as LED’s or PIR’s, and by proactively tracking energy consumption and making operational changes as required. Good waste management practices include proper disposal of different waste types as required by government guidance. Managing energy and waste effectively not only reduces a business’s carbon footprint, of which the built environment produces 40 percent of the worlds total carbon emissions, but can also deliver cost savings. Elmualim also identified the key drivers for sustainable Facilities Management in the UK. Overwhelmingly, pressure from clients, employees and stakeholders, organisational ethos, corporate image and legislation were the key drivers for a sustainable approach to Facilities Management (Elmualim, 2012). 66% of Elmualim’s respondents cited legislation as the foremost driver for adoption of sustainable facilities management practices. 61% of respondents placed corporate image as the second most important factor. The study found, quite surprisingly, that less than 50% of respondents perceived organisational ethos and other pressures, such as senior management leadership or directives as key drivers for adoption of sustainable facilities management practice. The type of organisation the respondents were from also had an effect on adoption of policies. The level of sustainability policy was highest in governmental organisations (93%), and annual turnover greatly increased the likelihood of an organisation adopting policy. Smaller organisations, conversely, were less likely to adopt a sustainable facilities management framework. The survey findings showed 100% of organisations with an annual turnover of over £1bn had a sustainability policy implemented. Only 63% of organisations with 10-49 employees had a sustainability policy implemented. This shows a lack of awareness, or a lack of investment by smaller organisations in sustainable practices, despite the benefits in terms of cost and emissions reduction offered by adopting such practices. Meng, 2014, identified the concept of sustainable facilities management, positing a need for sustainability considerations throughout an organisation to be woven together. The strategic decisions made in the name of sustainability must filter down to the operational level of an organisation. Only through facilities managers having appropriate knowledge of practices and technologies can a framework for sustainability be created. Equally a framework of sustainability throughout an organisation will only be sustained through education from top to bottom; raising and maintaining awareness of the impact small everyday decisions in terms of the environment. Sustainable practices should be incorporated into a business at an operational level, with the guidance and processes developed and implemented by the facilities manager (Meng, 2014). Sustainable Facilities Management can be identified as a business function which manages, implements and delivers improvements to the economic, social and physical environment, while supporting and enabling a business to meet its commitment to environmental sustainability, and core business objectives (Tucker, 2013).

Sustainable Facilities Management does not create new functions within the industry, but rather requires facilities managers to adopt new strategies and management practices. Tucker identified a set of core functions which could be revised to assist in delivering sustainable business practices, some of which are relevant to the retail sector; Cleaning (reduction of water usage, use of non-toxic chemicals), Catering (locally sourced produce, biodegradable packaging), Travel, Waste disposal (recycling, colour coded bin systems), Energy (reduction in use through timers, PIR’s, energy recovery) (Tucker, 2013). Elmualim identified three areas which organisations prioritised over other areas of sustainable Facilities Management: waste management and recycling, energy management and the carbon footprint. These three areas were followed by H&S, sustainable travel, productivity, biodiversity and building disposal. The study found a disparity between the prioritisation at a strategic level as part of the sustainability policy, and the operational focus on different aspects of sustainable practice. While the overall policy held waste management and recycling, energy management and the carbon footprint to be the priority, the facilities management team prioritised delivery of energy management, waste management and recycling and health and safety. The decision to do so could be driven by legislation; however it could be driven from a personal perspective. Energy consumption is easy to control through passive technologies and setting limits; for example PIR's, LED's and time controls on HVAC. Waste management is heavily dependent on people using the processes and systems correctly; it can be difficult to change people's attitudes towards waste and recycling, and therefore could be seen as a waste of time or resources by Facilities Managers's as there will always be a degree of non-compliance.

Adeyemi (2009) noted that much of the building stock for the next century already exists and thus, to make a serious impact on improving sustainability, existing buildings should be more fully considered, so that fewer resources may be consumed by new builds.

Many large scale, corporate retail businesses tend to have a cycle of refitting shops to modernise and update their fitout, in line with evolving customer trends or brand image. From a sustainability standpoint, this is the perfect time to implement sustainable technologies or practices. Research by BRE shows that choosing sustainable options in the development and construction of property has little to no impact on the overall capital cost of a project. BRE is the organisation associated with BREEAM ratings. Originally the purpose of BREEAM was to assess new buildings on the merits of their sustainability practices, which has since had the scope increased to include retrofitted buildings as well. A BREEAM assessment takes into consideration a variety of sections and issues, which are rated. An overall BREEAM certificate is then issued for the building.

Sections and issues	
Management	**Health and wellbeing**
– Project brief and design – Life cycle cost and service life planning – Responsible construction practices – Commissioning and handover – Aftercare.	– Visual comfort – Indoor air quality – Safe containment in laboratories – Thermal comfort – Acoustic performance – Hazards.
Energy	**Transport**
– Reduction of energy use and carbon emissions – Energy monitoring – External lighting – Low carbon design – Energy efficient cold storage – Energy efficient transport systems – Energy efficient laboratory systems – Energy efficient equipment – Drying space.	– Sustainable transport solutions – Proximity to amenities – Maximum car parking capacity – Travel plan.
Water	**Materials**
– Water consumption – Water monitoring – Water leak detection – Water efficient equipment.	– Environmental impact of materials – Responsible sourcing of materials – Designing for durability and resilience – Material efficiency.
Waste	**Land use and ecology**
– Project waste management – Recycled aggregates – Operational waste – Speculative floor and ceiling finishes – Adaptation to climate change – Functional adaptability.	– Protection of ecological features – Enhancing site ecology – Long term impact on biodiversity.
Pollution	**Innovation**
– Impact of refrigerants – NO_x emissions – Flood risk management and reducing surface water run-off – Reduction of night time light pollution – Reduction of noise pollution.	– Innovation.

Figure 3: BREEAM No-Domestic Refurbishment Issues

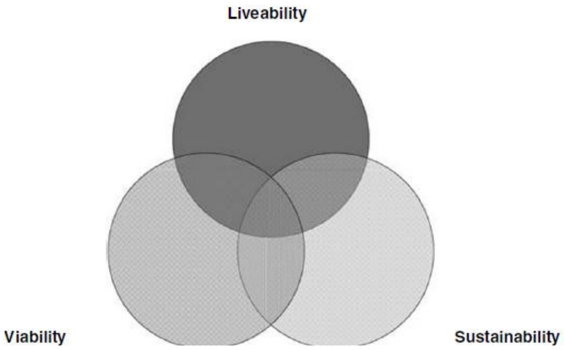

Figure 4: Interaction between Viability, Livability and Sustainability

The relative costs, related benefits and constraints of reuse vs. demolition and new build have received widespread debate, with Hall (1998), Douglas (2006) and Kohler & Yang (2007) also stating that the costs of reusing buildings are lower than the equivalent costs of demolition. Shipley, Utz & Parsons (2006) however advised that it is potentially cheaper to improve than to demolish and rebuild as long as the structural components already exist, and the cost of borrowing is reduced, as contract periods are typically shorter." Needleman (1965) once argued that, attention should be directed to improvement than to rebuilding, because rebuilding would normally cost more than renovation, and the rate of rebuilding is relatively slower than improvement in raising the quality of the general housing stock. Sigsworth & Wilkinson (1967) however criticized Needleman's model, noting that the "two options should deserve equal attention" rather than only attaching the importance to the option of improvement: improvement should be applied to buildings capable of modernization, while rebuilding is necessary where existing buildings "are too worn out to be renovated." Douglas (2006) is of same opinion, he wrote that, demolition is often selected when the life expectancy of an existing building is estimated to be less than a new alternative, despite whatever improvement may inject. Dong (2002) conducted a detailed comparison of the options of improvement and rebuilding, and contended that improvement outweighed rebuilding in terms of a lower cost and higher resource efficiency, "while rebuilding had advantage in reducing the impacts of global warming potential." On the contrary, Bullen (2007) believes that since new build is comparatively more straightforward, then costs are often lower than improvement.

Figure 5: Relation between Liveability, Sustainability and Viability

Notwithstanding the evidences clearly suggesting that improvement has significant long-term benefits to offer, the decision as whether to improve or demolish can be exacerbated by an array of interacting variables that converge around financial issues. Accordingly, when considering a building for improvement, it is essential to also examine the following issues as noted by Shipley et al. (2006), Itard & Klunder (2007), and Bullen & Love (2010): - building's structural layout and its capacity to accommodate required spaces and functions; - energy efficiency of the building's walls, windows and roof; - building's potential for meeting building, heath, safety and accessibility requirements; - condition of mechanical, plumbing and electrical systems and their capacity for modification; - the presence of hazardous materials; - ability of the building and site to provide a safe and secure environment; and - convenience and safety of the building's location.

Although there is a significant amount of research into retrofitting or adopting sustainable technology, such as LED lighting, and practices into commercial office buildings there is not as much research into use of sustainable technology and practices in retail properties (Miller, 2009). Commercial property accounts for 9% of total energy usage in the UK. Within this 9%, retail properties use the most energy on account of the requirements for large floorspaces and greater energy used per square foot. A study by Marks and Spencer comparing the relative merits of energy consumption and reduction in carbon footprint highlight the problems with retrofitting retail units in the UK. Between 2003 and 2007 M&S reduced their carbon emissions by 30% per square foot. However the contributions towards this figure from different "eco stores" was not uniform. For example, a store in Bournemouth which was refitted with sustainability in mind, but constructed in 1930, achieved an energy saving of 25% and CO2 by 92%. Conversely, a brand new store in Glasgow saved 55% of energy and 95% CO2. This highlights one of the biggest problems with sustainable refits in the retail sector. Older buildings were not designed with energy efficiency or sustainability in mind. Given the circumstances we have to ask whether BREEAM ratings can ever be applied to retrofitted buildings constructed before energy efficiency and sustainability became a driving factor of structural design; or if the payoff of holding a BREEAM certificate, or even pursuing a "green" retrofit is commercially viable if the work and cost involved is significant comparative to the perceived value of holding sustainability credentials in terms of design. As Thompson notes, the factors of sustainability, viability and livability are entertwined, and ultimately the decision on whether to pursue, and the limits to the extent of, a green retrofit must be informed by a balance between these factors (Thompson, 2007).

The main aspect of the Sustainable Facilities Management is its contribution in the battle against climate change. It is estimated that only 5% of generated energy is used in the construction process and 45% is used in order to power and operate the buildings (CIOB, 2004). The Organisation for Economic Co-operation and Development (OECD, 2003) highlighted that buildings consume about 32% of the world‟s resources and that includes 12% consumption of water. The emission of CO2 as a result of such large consumption is enormous and its contribution to the problem global warming is significant. In this respect, there is a great potential for substantial reductions of these patterns and following that, the substantial reduction of the detrimental effect that it exerts on the environment. (Ludlow, 2009)

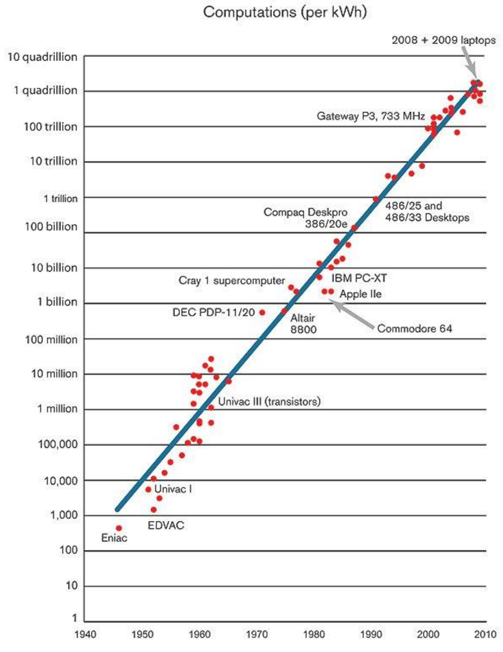

Figure 6: Change in number of computations possible per kWh over time

Broadly speaking, there are three main culprits in energy use within the retail sector; lighting, heating/cooling and equipment. Lighting is key for retailers to display stock and ensure the store is inviting to potential customers. Heating and cooling is important to maintain a comfortable environment in any retail unit, but may be more important if a retailer has a focus on cold goods. Equipment contributes to the requirements for heating and cooling through its generation of heat, with 1 watt of power requiring 1 watt of cooling power. The more equipment in a shop, the more cooling is required. Thompson noted several tactical responses to these three consumers of energy. For equipment, low energy devices are now widely available; the amount of energy required to carry out the same function by a computer is predicted to reduce by a factor of 100 every decade (Koomey, 2012). This trend is most recognisable in the rapid advancement of smartphones and other miniaturised computer technology, such as apple watches. A personal phone now is more powerful than a home PC 10 or 20 years ago. Advancements into display screens with lower power requirements also contribute to a reduction in the wattage required by equipment; LCD's use far less power than CRT monitors. Although there is scope to lower energy usage by swapping to (now industry standard) small form computers and cash registers, the capital cost of investment is unlikely to be paid back within the lifecycle of the product. In terms of lighting, traditional incandescent bulbs waste a huge amount of heat and energy. Switching to low energy bulbs is a simple method to reduce the energy consumption and cost, with minimal capital investment, as existing fittings can be utilised; just swap the bulbs out. For a longer term investment, fittings can be replaced with

LED; however the reasoning for use of LED fittings is not necessarily invested in a reasonable payback period. There are other benefits though, namely long warranties, long life (over 50,000 hrs), reliability and flexibility in designing bespoke window displays. For a larger retail business, the cost for LED fittings could be reduced through value engineering, by standardising the types of fittings used for shopfits, buying in bulk and driving the cost down.

Dixon (2014) noted several elements of the commercial property sector which ought to drive a push in green retrofitting within the sector. He estimates the UK business sector is overlooking approx. £1.6bn in cost saving due to under investment in energy efficiency, with the UK's commercial retrofit market potential estimated at £9.7bn. There are several characteristics which are key to understanding how retrofit activity within the sector operates, and why there is little research or push towards commitment to green retrofits in the sector. Firstly, there is a higher level of tenant property in the commercial property sector. Over half commercial property is rented, compared to only a third of housing. This is due to businesses becoming reluctant to commit capital and management required when owning a property, and market forces allowing businesses to take advantage of sale and leaseback deals, driven from high prices in the mid-200's. Second, the sector is an important part of the UK economy, valued at £717bn, with retail valued at £227bn taking up the largest portion of the market. Third, average lease lengths in the sector are falling. The average length of a lease in 2011 was below 5 years, compared to 8.7 years in 1999. Over 75% of new leases have a duration not exceeding 5 years. Fourthly, as noted by The Carbon Trust report *Building the Future*, the property sector is complex, with a diverse range of building types. By its nature the sector is risk adverse and conservative, which contributes to withholding investment when retrofitting is concerned.

Dixon's research goes on to identify the key stakeholders in the commercial property retrofit regime, what is meant by retrofit and what technologies are already being used, examines the key drivers and barriers for commercial property retrofit, and how commercial property retrofitting is delivered, including frameworks, legislation, financing and monitoring. Dixon interviewed 37 senior people from across the property industry. He found that green commercial retrofits were generally carried out at a building level, which was usually driven by owner occupiers, or landlord investors. Tenants did not tend to commit to green retrofits.

As noted by Adeyemi's paper on Sustainability and Maintenance, the rate and scale of improvements needed to existing buildings to "save the planet" are immense and extensive programmes are seen as necessary (Wood & Muncaster, 2012). It would be difficult to achieve SD in our cities if the issue of existing buildings is not addressed since they form the bulk of buildings. Wood (2006) noted that, "No building is an island. Buildings relate one to another and to the infrastructure, which links and serves them and their users. There are, for instance, cultural, heritage and physical links to be built upon and added to by new buildings and improvements to existing buildings." Hui, Wong & Wan (2008) added that, not only does improvement extend the economic life of existing buildings; it also improves "the living environment, increase property values, reduces the urgency for redevelopment, and enhances public safety and the image of city". One benefit, as observed by many authors, is that when a building standard is sustainably improved, it is expected that the maintenance cost would considerably reduce. Grigg (1998) had noted that "maintaining infrastructure is a constant and expensive process which often is neglected in favor of more attractive political goals." Adequate maintenance financing is but one of the major factors affecting the sustainability, because poorly managed infrastructures steadily deteriorate, become congested, or become unsafe and clearly are not sustainable. Douglas (2006) also argued that, compared to newly built, improving existing buildings "would postpone, if not avoid the obsolete process of buildings and it will greatly enhance their performance". Kincaid (2002), in one UK study showed that post improved office buildings had lower operating costs than prior to the improvement intervention, even if sustainability was not a priority, while Suzuki, et al. (2010) advised that “the principles of sustainable development must take into account and carefully assess the costs of sustainable development investments by calculating and considering the ‘operational costs’ after construction is completed. In other words, operating and maintenance costs should have continuity so as not to ‘burden’ in the future.” Improvement entails the upgrading of existing buildings’ original standard at construction, and while many other terms have been used in literature to describe its strategies, such terms have not been used in this paper save in relevant quotations in a bid to produce consistency. Such terms include adaptation, refurbishment, rehabilitation, remodeling, retrofitting, revitalization, among others; they have ambiguous meanings, as observed by some authors.

The terminology “retrofit” was found to be of significance in Dixon’s paper, and debatably interchangeable with “refurbishment”. Dixon found that there was indeed a perceived difference between “retrofit”, which was seen as a light touch introduction of energy efficiency measures while the property was still in occupation, whereas “refurbishment” denoted a deeper level of refit with changes to the internal and external fabric of the building. However not all interviewees drew this distinction. Dixon determines that there needs to be a clearer consensus on the terminology and its application, as a lack of understanding on the difference between retrofit and refurbishment could be hampering adoption of green retrofits in the commercial property sector. He also notes the RICS does not explicitly draw a difference between the two concepts, and suggests defining retrofit in terms of commercial property as “non-intrusive whole system upgrades carried out during lease of during ownership”, compared to refurbishment, characterised as “major alterations to the fabric and or services at a systemic, whole building level, carried out on lease renewal or lease end”.

When asked about key technologies adopted in their buildings, Dixon’s respondents reported the top items were energy efficient lighting and controls, management systems (BMS), and building services (boilers, pumps etc), all of which are perceived as easy wins. In terms of cost and implementation, these items are generally off the shelf and do not require a significant investment; indeed, LED lighting and energy efficient HVAC systems are now the industry standard. A single LED tile can now be purchased for as little as £30. In terms of the retail environment it is hard to justify non-adoption of low energy bulbs or LED panels when refurbishing shops. Issues such as behavioural change, or water efficiency systems were not emphasised as much, despite having a high impact on annual energy savings. However behavioural change may come increasingly easier to implement as the awareness of sustainability issues is raised, and more people get on board with changing the direction humanity travels in. For example, this summer The Body Shop have implemented anti-pollution adverts on bus stops across London, incorporating air cleaning technology developed by Airlabs to raise awareness of carbon emissions in the City. Water efficiency systems are not commonly adopted in the retail sector due to the emphasis on the front of house areas; back of house services and facilities take a back seat and tend to lack investment.

The most important drivers from Dixons research were policy, economic factors and marketing/brand/reputation. Membership of carbon reduction schemes, or compliance with legislation such as the Energy Act 2011 (which will make it unlawful for buildings to have a EPC rating of F or G2 from April 2018) were key drivers in committing to green retrofits. The aforementioned Paris Agreement will undoubtably drive the takeup of green retrofits in future. Compliance with policy is key in maintaining and improving the sustainability image of a company or brand. In a study by Unilever conducted in 2017, there was a noticeable trend towards consumers favouring companies and products which committed to the sustainability agenda. The study of 20,000 adults from five countries showed 33% of consumers were buying from brands based on their social and environmental impact, and that there was an estimated 996bn Euro opportunity for brands who make their sustainability credentials clear. One in Five respondents surveyed stated they would actively choose brands is they made their sustainability credentials clear. This shows that in the UK retail sector there is an incentive for companies to go green to protect and improve their brand image. Shouting about green credentials doesn't just have to be in terms of products sold, it can also involve macro level reporting, such as reduction in C02 emissions at a company level, which could be influenced by green retrofit practices. The main barriers to green retrofitting were unsurprisingly cost/value, and organisational issues. From this we can draw the conclusion that financing is critical to success of adoption of green retrofits in the commercial property sector. Due to the risk adverse nature of the sector, investment in green technology must be seen as worthwhile in terms of commercial value to a business. Despite the potential market value of consumers who spend with sustainability in mind, it is difficult if not impossible to measure this in terms of company performance. If there were hard incentives for companies to commit to green retrofits, we may see an increase in their adoption. Dixon also states transparent display of energy performance should be mandatory in the sector, playing on the image element of compliance with green retrofits as per respondents comments.

In order to improve the commercial viability of green retrofits, there have been attempts by scholars and market entities to standardise the application of green retrofits. LEED-EB and LEED-EBOM (LEED-Existing Buildings: Operations & Maintenance) are frameworks which can be applied to green retrofitting existing buildings, covering 69 possible points and 7 prerequisites. Areas of assessment include Sustainability, Water Efficiency, Energy, Materials and Resources, Environmental Air Quality and the Innovation and Design Process. Studies by Delp (2009) recommended LEED-EB and LEED-EBOM as a basis for green retrofit in terms of municipal redevelopment, however it should be noted the LEED system may not be applicable to the UK property sector. Delp noted a three stage process for identifying buildings suitable for a green retrofit. First, he suggests using utilities data to develop a view of its consumption to identify and prioritise buildings which a poor energy usage rating. Second, he recommends conducting site specific surveys to gather deep data necessary for producing recommendations for energy, water, renewable energy and mechanical systems retrofitting. Lastly, he advises conducting a second building walkthrough to assess the building on the basis of the LEED-EB checklist to determine how close the building is to achieving LEED-EB Silver certification. Delp developed four measures of success or viability for buildings with a potential for green retrofit. First, and most obviously, the potential for cost savings in terms of the individual building and the organisation who leases the building as a whole. Second, the potential for green job creation, and whether the retrofit would stimulate jobs and growth in a given sector, whether directly or due to a ripple effect providing jobs to industries outside of the immediate retrofit. Third, the potential for reduction in greenhouse gases. Whether the retrofit would directly reduce greenhouse emissions or passively reduce them by reducing load on the overall energy sector. Fourth, he noted the potential for health and safety increases through improved air quality, lighting, and other comfort elements for building occupants. Muldavin (2015) developed a framework for investors to calculate and present the value of deep retrofits to investors, in order to make the decision making process easier, and thereby increase the attractiveness of green retrofits. Muldavin noted retrofit costs are difficult to calculate and present accurately, and are often misunderstood and misrepresented due to the difficulties of forecasting. The majority of studies are based on the green potential of new developments rather than green retrofits. The report noted green retrofit projects have little cost premium if timed correctly with other capital improvement projects, and if the project follows best practices in terms of design, planning and investment. The gross development cost depends on a myriad of factors, including the building type, location, the experience and management expertise of the team delivering the project. At a maintenance level following the implementation of the project, the quantification of energy saving and the cost implications of the savings in energy are difficult to quantify, but are key in swaying the decision makers in a given business. In order to present the value of green retrofits, Muldavin suggests offsetting the costs of the green retrofit against the running costs of a business over time. Given a building requires gradual improvement as assets wear out over time, the implementation of green retrofit technologies, such as LED lighting, can be quantified by the long term benefits; an LED bulb or fitting's burn time is significantly longer than a fluorescent bulb of the same wattage. Muldavin also notes that there are often incentives supplied by local or national governments to upgrade asserts to green equivalents, which could further improve the commercial viability of a green retrofit. He identifies two main approaches to quantifying the retrofit development costs. On the one hand, we can carry out assessment on the basis of individual assets. For smaller buildings this may be a suitable method for assessing viability, however on larger more complex buildings the viability of a green retrofit may have other benefits which are not quantified as part of an individual asset assessment. For example, if one upgrades thermal insulation for a larger building, there will be an impact on the heating and cooling element of a building; which could mean the overall viability of both projects is increased as they support each other. He notes the key to presenting the costs to investment decision makers is that the complexity of how different elements of a green retrofit support each other is outlined and presented. This detail could be key in swaying a decision maker from the fence into the presenters pocket. By including the financial impact on all aspects of a building's management we can more accurately quantify the benefits to the business. Ayyad (2016) developed a formula to support the decision making process, the Green Retrofitability Index (GRI). He noted that most green retrofit surveys are conducted by trained architects or surveyors with the intent of tendering and implementing green retrofits as part of a larger project. He noted that these surveys do not tend to give a full scope of the benefits a green retrofit could provide in real terms. The people making investment decisions in businesses are generally not made by people with sustainability or facilities management in mind; indeed in many cases the role of the facilities manager or team are downplayed in favour of commercial viability. This makes the decision making process difficult as the benefits of a green retrofit are difficult to quantify in terms of investment decisions. Given the benefits are not generally tangible assets people shy away from committing to green retrofits outside of major project works; generally the decision to implement the retrofit would be taken as part of a larger decision to refresh a building, most often when the lease for the tenant comes to an end and the building changes hands to an incoming tenant. The GRI takes into account a variety of factors which would affect the decision making process and puts them into a formula which gives a definitive level of green retrofitability. Elements include the building's market value, energy consumption, water consumption, lifetime, level of heat dissipation (U-Value), air infiltration rate, occupancy rate, age of the building, and built up area. A High GRI (maximum 100) would suggest a building which is very suitable for green retrofitting. A low or 0 value suggests a building which Is already designed with green principles in mind, or is not suitable for a green retrofit for other reasons. It should be noted that Ayyad's framework also deals with larger scale retrofits, possibly into the realms of refurbishment as previously defined by Dixon. The GRI also tends towards larger buildings rather than small scale businesses with significantly lower investment power an potential. However, it is reasonable to take a look at his work and adopt and adapt the theory into the UK retail sector, a large proportion of which are small or medium high street businesses.

To summarise our reading around the subject, we have identified the concept of sustainable facilities management and it's role within the sector. We have identified how sustainable facilities management has improved and increased in importance over time, alongside the growth of the facilities management sector as a whole. We have noted that there is a definite problem with companies investing in sustainable practices and policies due to the perceived lack of benefit. We have identified how larger corporations with more money and employees are more likely to have a sustainable facilities management framework in place, compared to low take up in smaller buisinesses. We have looked over how green retrofits can be a cost effective method for upgrading buildings and improving their sustainability credentials. We have looked at methods for quantifying the investment for green retrofitting in terms which are palatable to key stakeholders within organisations. All of these pieces of research have influenced my choice to focus on green retrofitability within the UK retail sector. As noted although larger businesses have the means and money to invest in green retrofits, the perception of smaller businesses may be that the cost is a major hurdle with no real quantifiable benefit. I do not believe this is the case, and think that there may be some minor upgrades which any business can afford to reduce a buildings carbon footprint and decrease costs longer term.

Research Design and Methodology

The aim of our research is to determine whether the principles of green retrofitability can be applied to small to medium retailers in the UK retail commercial property market. To narrow the research question, we will only be looking at retailers under 2500 square foot. Furthermore we are looking at retailers in Buckinghamshire, as the historic county has a good mix of building types, constructed at different times.

We have looked at a wide array of articles in relation to key topics in sustainable facilities management and green retrofitting on a large scale. I would like to investigate further the application of green retrofit strategies in terms of electricity consumption; what practices are commonly used when retrofitting retail units in the UK and what kind of practices could be adopted. As we have discussed there is a certain level of resistance in the commercial property market to green retrofitting. Using influence from Ayyads GRI framework I will look at whether there are factors in the UK retail market which influence adoption of green retrofit technologies. The terminology of retrofit will be taken to mean procurement and installation of green technologies while the retailer is still in occupation of the unit, or has to vacate the unit for a short period of time. I will examine what current technologies are used in terms of electrical consumption in relation to a theoretical estate of small, medium and large shops, and compare and project consumption data and payback periods based on the estate adopting a green retrofit strategy, using qualitative information fed into excel to create models of consumption for green and non-green shopfits.

Using the Radius Data Exchange, provided by the Estates Gazette, I will create a portfolio of shops from information available on the Exchange. The benefit of getting information from the Exchange is that it allows us to see square footage of real estate deals. Using the square footage as a guide, I will separate the portfolio into three types of unit: Small (under 500 sq ft), Medium (500-1500 sq ft) and Large (1500-2500 sq ft). We will make assumptions regarding the number and type of electrical assets in each building. We will then calculate assumed consumption data for traditional and LED light fittings as a measure of an easy win in green retrofits, and also look at alternative technologies, such as PIR's or battery power systems, to see if the impact of consumption and payback period is economically justifiable in terms of lease length and rental costs.

I will be using quantitative data sources in favour of qualitative data sources because it will allow me to develop a framework and results without resorting to interviews. When approached about information such as energy consumption or green retrofit credentials, companies have not been as willing to assist with qualitative interviews as initially thought.

This reluctance to be open to approach regarding the subject could be seen as an indicator that the companies in question are lacking when it comes to commitment to green technologies. The benefit of focusing on technology implementation, which is measurable and quantitative, rather than sustainability practices is that we can model the lifecycle of a product and its full impact/carbon footprint. Sustainability practices cover a wide range of adoption, and are very personal to the individual. Although many people say they recycle 100% of the time this is simply not the case. Sustainability is therefore a difficult topic to interview people about, as they may not tell the whole truth, or may exaggerate their commitment to the sustainability agenda, which would impact the validity of the study. Despite there being methods to overcome or mitigate this effect, I did not feel the use of qualitative research methods was useful in this instance. The best people to approach for a qualitative interview piece would have been those higher up in organisational structures, who may not have had the time or commitment to undergo an interview process with someone outside of their organisation, who they know little about, on a topic which is often a touchy subject.

Sustainable technologies are measurable. We can find information or predict the energy and resources required to manufacture and ship the product in the first instance. We can also predict the costs and energy needed to install, and the lifecycle consumption and end of life disposal costs for products. With this in mind, focusing on items such as LED lights gives us far greater control when building a quantitative data model. All the information needed to create a model is in the public realm. Unfortunately EPC ratings for commercial buildings are not actually available to the public, which would have been a great asset in creating data sets for analysis. Enabling us to see a true picture of EPC ratings in retail buildings would have allowed us to make more accurate decisions when assuming what kind of technology already exists in the mock portfolio used to model our data.

Research and Findings

To conduct our research we have created a mock portfolio of 31 buildings based on and using information from Estate's Gazette 's database. The portfolio covers a range of different buildings in different locations. UK retail stock covers a wide range of different buildings, from different time periods using different construction methods. This means in some areas, retail units have significantly lower properties which contribute to sustainable goals of a retailer. Modern buildings are often built from the ground up with sustainability in mind, using cutting edge construction techniques such as prefabricated cladding panels, double or triple glazing and fully sealed environments with integrated HVAC systems to minimise energy loss and reduce the overall carbon footprint. Indeed, modern construction methods attempt to minimise the impact on the environment at every phase of design, construction and use. Unfortunately this was not the case in years gone by, giving us a reason and scope to suggest upgrades for older buildings in terms of green retrofit. To be clear at the outset of this piece of research, we are referring to retrofit as a low level set of upgrades which can be carried out while the unit is still in occupation or with minimal downtime to the tenant. A refurbishment, looking at the fabric of the building, is not covered in the scope of this research. The appraisal of green retrofitability of a retail unit can be defined by the following categories:

- Analysis of building stock
- Cost effectiveness of purchase and implementation of equipment
- Quantification of energy saving potential

We will look at each concept in turn in relation to the portfolio which has been developed.

To begin with, we used the Estates Gazette's radius data exchange to look up and download a list of all occupational deals in the retail market for Buckinghamshire from the beginning of the radius data exchanges records on the market. I chose to use Buckinghamshire as opposed to more urban areas such as London due to the wide variety of building stock. There is a good range of building types and construction methods depending on where you look in the county; in High Wycombe alone we can see 19th Century construction in the old town of West Wycombe, compared to the postwar housing and shops of the main town. Understandably, this gave us a lot of information to work with at a base level. By filtering the data on the basis of assumptions and removing information irrelelevant to the research, I am able to look in more detail at individual units. In order to filter the information we had to make some assumptions about the building stock, and apply said assumptions to the data gatherered to reduce the size of the data set, and ensure we are targeting the research to applicable units.

The initial data gathered from EGI identified 9 different types of retail unit; General Retail, Shopping Centre, Restauraunts and Cafes, Mixed Use Retail, Hot Food Takeaway, Retail Park, Professional, Financial and Professional Services, and Financial. I decided to proceed with units which were identified at “General Retail” at the expense of the other types of retail unit. The reason for this decision is that units marked as General Retail appeared to be High Street units of varying types, and therefore more likely to benefit from a green retrofit. Shopping centres tend to have standards of shopfitting and house higher end tenants, which are more likely to have already committed to green, sustainable technologies in their fitouts. Shopping centres themselves generally tend to support sustainability policy and expect such behaviour from their tenants. Restauraunts and Cafes may benefit from green retrofit practices, however due to the nature of their business they require use of fixtures not found in general retail units. It is difficult to quantify or make assumptions about cookers, microwaves and the like, on the basis a restaurant or café’s footfall fluctuates significantly, which will have a significant impact on the amount of power, fuel and water used. The same issue applies to hot food takeaways. Units in retail parks tend to be big-box units, with larger tenants. In general, either the cost to carry out a green retrofit on such a large scale, in a unit with high level ceilings requiring extended use of access equipment to replace light fittings, would not be deemed suitable. However a green retrofit could be viable at the end of lease with an incoming new tenant, should they make significant changes to the layout; this then would fall more under refurbishment, making these type of units inclusion in this research obsolete. I took Professional and Financial Services to mean banking facilities or institutions such as travel agents. Due to the broad scope and style of fitout in these type of retail units I chose to omit them given the difficulty in making assumptions about them. Mixed Use retail only constituted 2 units on the list taken from EGI, and were omitted on the basis they did not conform to the normal idea of high street retail. Giffard Park Centre for example is a unit which comprises several businesses under one roof, such as dry cleaning.

From the remaining units marked General Retail, we decided to only look at sites with their leases agreed in 2018 in order to reduce the size of the data set. We further refined this by looking at deals which were for leases or lease renewals. In order to assess the properties green retrofitability in terms of payback periods, we had to look at retail units where the annual cost of the lease was available. Using these criteria, the initial data set of approx. 1400 units was cut down to just 31, enabling us to look at each unit in a bit more detail. With this varied portfolio in place, we then made some assumptions on the basis of the building design and assumed construction method.

Analysis of Building Stock

The portfolio we have created covers a wide range of construction methods, which have different characteristics when considering the impact the building design has on its natural ability to conserve energy. The following building assessments are indicative to the entire portfolio, as we have taken one site which reflects the construction method used for several sites from the list.

31 West Street, Buckingham – 19th Century Town

The construction of 31 West Street, Buckingham consists of Flemish bonded brickwork, which means the wall will be a solid construction without a cavity. This means there is no scope to improve the insulating properties of the wall by introducing cavity wall insulation into the building. The windows on the upper level are single glazed sash windows, which are good for ventilation, but will allow heat to pass through easily during winter months. The ground floor or retail level of the building also appears to be single glazed which will not contribute to energy conservation. The doors and window frames are wood, which do not lend themselves to retaining heat very well. The use of this kind of window, and the bond of brickwork suggests a building constructed before the 1920's when cavity walls became the preferred method of wall construction. As such we will assume this building was constructed in the 1900's. We will therefore class this building as "19th Century Town".

7a High Street, Princes Risborough – 19th Century Village

Princes Risborough is an incredibly old town, with a mention in the Domesday Book. Although certain parts of the town consist of more modern construction, the High Street still largely consists of older buildings. 7a High Street is a small retail unit constructed using Flemish bonded brickwork, with a terracotta tile roof. Although the windows on the upper levels appear to have been replaced with double glazing at some point, we can see from the adjacent estate agents that the unit will have had single glazing at some point. The ground floor has retained its large, wood framed single glazed windows.

12E Packhorse Road, Gerrards Cross – 20th Century Commercial

This building, Pilgrim House, is endemic of 20th Century construction. Utilising a concrete frame with brick cladding, this site uses a stretcher bond, which suggests the building was created with a cavity wall on the upper levels, which is likely already insulated. The roof is a flat roof which although not great for drainage is likely well insulated. We can see from satellite imagery that the roof is entirely black, indicating a felted roof, possibly over a concrete top. The windows of the building appear to be double glazed. I would safely assume the building has a suspended ceiling throughout. Overall this building ought to have good energy conservation compared to other buildings in the portfolio owing to its design. There are several other sites made in a similar way in the portfolio.

186 New Road, High Wycombe – 20th Century Residential (Converted)

This site on New Road, High Wycombe, appears to have been constructed after the Second World War. The visible brickwork on the upper levels is of a stretcher bond, suggesting a cavity wall, which will likely have already been insulated. The ground floor has large windows, however these windows are double glazed. Internally, this site has a suspended ceiling, which allow for improvements to lighting an insulation with ease. The roof is tiled, likely with insulation built underneath it due to the age of the unit.

XScape, Milton Keynes – 21st Century Commercial

XScape in Milton Keynes was completed in the year 2000. At 44m tall, it is an iconic, if not the only, part of the Milton Keynes skyline. XScape is a building unlike any other on the portfolio in terms of footprint, usage and fitout. Given this, it is very difficult to make assumptions about the current status or values of the building. However, we can assume that the building was constructed with a degree of sustainability in mind owing to its construction techniques; lightweight steel and glass throughout. We will use the assumptions made for this building as a benchmark for other constructions built since the year 2000, given the similarity in actual construction method and building services, despite the differences in the outward appearance of different buildings.

As we can see the 31 buildings across the portfolio can be broken down into five distinct categories: 19th Century Town, 19th Century Village, 20th Century Commercial, 20th Century Residential (Converted), and 21st Century Commercial. We have assigned the key assets within the building with values based on averages available on the designing buildings wiki, which are taken to be the industry standard values. We will now look at each asset in turn, and determine what, if anything, can be done to upgrade the asset.

Green Retrofit Upgrade Specification

In terms of a specification for retrofitting retail units with sustainable technologies, there is no one size fits all option. Indeed, some buildings may not be suited to receive such upgrades, for example buildings with Flemish bonded walls will be more difficult to insulate than buildings with cavities built into the walls ready to accept insulating material. As we have identified five types of buildings in the portfolio, It is reasonable to build five different retrofit upgrade specifications on the basis of what is visible from the photos of the buildings and our assumptions on the way the building is constructed. We will also make the assumption that the building to be upgrades exists as-is; in that there are no pre-existing upgrades to the building. The reason for this is that some of the buildings in the portfolio, for example the 19th Century Village building in Princes Risborough used as an indicative specifimen in the previous section, have received double glazing upgrades at some point. On this basis we can assume other upgrades may have been made to other buildings in the portfolio. The purpose of this research is to take a base line example of a particular type of building and recommend a series of upgrades, as opposed to make site specific recommendations. As such we will not take pre-existing upgrades into account.

Walls

There are two types of brick wall identified in the portfolio; Flemish bonded and stretcher cavity wall. As noted by the governments Building Research Establishment (BRE), insulation of solid brick walls is one of the greatest challenges to upgrade in the UK. It can be significantly more expensive to insulate a solid brick wall when compared to a cavity wall. Research exists by the BRE which goes into great depth on U-Values of solid brick walls. The BRE noted that as part of EPC surveys the usual value of 2.1 W/m2K is adopted, given a U-Value test takes up to 10 days to complete, and therefore takes too long to be considered under the scope of an EPC. In fact their research found a great variation in U-Values of solid brick walls dependent on the thickness of the wall, bond type (rather the amount of mortar used in construction), and the dampness of the wall; allowing more accurate modelling of an EPC and cost savings associated with upgrading solid brick walls. For the purposes of this research we will stick with the usual assumption of 2.1 W/m2K given the portfolio is being assessed from a desktop, making measurements of wall thickness and dampness impossible. For upgrading solid brick walls in this portfolio, we will use Kingspan insulated plasterboard for our model. With a U-Value of just 0.018 W/m2K, this board is excellent for internal use. Using market data, we have calculated the cost per square meter (materials only) to be £19.66. For the calculations involving Kingspan, we will work from cost per square meter only, as opposed to quantifying the cost per pack of 21 boards, due to the intricacies of quantifying how many boards would be needed for specific sites.

For the cavity wall buildings, those we have assumed were constructed in the 20th Century, we will again refer to the BRE and EPC rating models for measuring U Values. As previously noted, it is quite likely that the cavity walls in the portfolio are already insulated; this is common, industry standard practice. If a building has a cavity wall without insulation, it is relatively easy to inject insulating material into the cavity. Discarding the more in-depth analysis by the BRE in terms of U-Values for cavity walls, again owing to their research requiring information on the depth of the wall, dampness etc, we will assume cavity walls in this instance have a U-Value of 1.5 W/m2K. In order to upgrade these cavity walls, we will assume the use of injected cavity wall insulation using polyeutheurane foam (PU Foam). PU Foam is the most effective way to insulate cavity walls which have already been built, and can result in U-Values as low as 0.22 W/m2K when used in a 100mm cavity. We will assume this value for our portfolio. Other options include installing rockwool, or beads, into the cavity. However these methods do not perform as well as PU foam. The downside to using PU is that it can be difficult to dispose of at the end of the lifecycle due to its chemical composition. In terms of cost, because the cost of application is very dependent on the man hours to install PU foam, we will use guidance from Insulation Info, a cost comparison website for wall insulation, who advises a cost between £22-£26 per square meter. We will therefore assume a cost of £24 per square meter for installation of PU Foam.

In order to calculate the overall cost and meterage of the walls in our portfolio, we must also take note of the ceiling height. We will assume a standard ceiling height of 2.8m throughout the portfolio, as this will cover the majority of units comfortably, given it is the "normal" ceiling height for the UK. For the units which are identified as 19th Century, we will assume the shopfront will be replaced with a double glazed shopfront. For the 20th Century units we will not assume replacement of the shopfront. This will be taken into account when calculating the overall requirements for insulating materials.

Windows

Throughout the portfolio there are a variety of window types, however these can broadly be put into two categories; single and double glazed. Although there is variation in the design of the actual windows and frames, all of the sites windows fall into one of these two categories. In the case of double glazed sites, namely the ones we have identified as being constructed in the 20th or 21st Century, we will assume the site's windows are already of a sufficient type of double glazing that the site does not require replacement or further upgrade to triple glazing. For sites with single glazing, those identified as constructed in the 19th Century, we will advise an upgrade to double glazed windows. Note although for the purposes of this model we are assuming an upgrade to double glazing is acceptable at these sites, in practice it may not be possible due to the buildings being listed, or simply not compatible with installing modern window frames due to the age of the building. Furthermore we are also limiting the scope of the upgrade to the shopfront only, given our focus is on the upgrading retail units. For businesses the main point of an upgrade is cosmetic. Anyone who has ever been in the back of house area of a shop knows it tends to be stripped back to the bare walls, with minimal services. Furthermore, the exact number of windows in a given building is difficult to estimate from the limited information we have; as we only have photos of the front of the units, we are unable to comment on the total number of windows at the rear of the unit. With this in mind we will not recommend upgrading the entire building to double glazing. We will estimate a cost of £2500 for a replacement shopfront, based on an average of various types of shopfront and associated assets listed on the RICS schedule of rates. The U-Value of the double glazed shopfront will be assumed to be 2W/m.k as per our assumption for the pre-existing double glazed units noted as part of the 20th and 21st Century buildings.

In order to determine how much of the building is taken up by the shopfront for the 19th Century buildings, we will assume the entire ground floor frontage requires double glazing to the standard ceiling height of 2.8m. We will assume two large panes of double glazed glass, and a single inward opening door. Because we are recommending the shopfront to be upgraded, we will ensure the calculations for the total amount of Kingspan required is amended to account for thermal insulation not being required at the front of each unit. This will be taken into account when quantifying the insulation requirements for solid brick walls.

LED Lighting

LED Lighting is very difficult to quantify in the retail environment, given many retailers choose to use lighting not only to illuminate the space, but also to accentuate the products they have on display. As such we must make an assumption about the number of lights in our portfolio. We will assume that all of the stores listed use fluorescent lights. The reason for this is that the although LED's were developed over 50 years ago, they did not come into prominence within the public eye until relatively recently. The reason for the recent trend in using LED lighting Is partially due to the invention of white LED's which are suitable as a replacement for traditional fluorescent or incandescent lights. Furthermore, the perceived long term benefits of switching to LED lights are significant, due to their lower running cost and a long lifespan. A 38w LED panel, the type used in standard suspended ceiling grids, costs approximately £20 from electrical wholesalers. The energy used by an LED light is approximately half that of a fluorescent bulb; although the bulb wattage might be the same, a fluorescent ceiling light uses two bulbs for every fixture. In a standard suspended ceiling grid, one would see a lighting panel approximately every 3 or 4 tiles. On this basis we will assume a lighting panel for every 2m2 of ceiling grid. One Square meter is equivalent to 10.7 square foot. To convert square foot to meters you must times the footage by 0.09. This information will be used when calculating the number of lights to replace across our portfolio.

Quantification of Energy Saving Potential

In order to quantify the energy saving potential, we took two separate routes, one for LED and one for the insulating properties of the respective types of insulation. The reason for taking two separate routes for quantifying the energy saving potential was to reduce the level of complexity involved in calculating the savings, it was easier to keep the benefits of the two assets separate.

For LED lighting, we assumed two 38w fluorescent fittings every 2 square meters to be replaced with a single 38w LED panel. The reason for assuming a fitting every two meters is based on the design often used in commercial buildings. Commercial and retail units often use a suspended ceiling grid with various assets and services fitted in the insulating panels. By assuming a ceiling grid system, we can easily quantify the assumed number of fittings. In practice, a retail unit will have a variety of different lighting types, often used to accent the products on odder. Furthermore we have not made any assumptions about costs to replace emergency lights with LED alternatives, we assume the same or similar cost for ease and simplicity. The implementation of LED fittings results in roughly halving the amount of energy used by the fixture. To quantify the potential we calculated the payback period, by multiplying the annual usage in kWH by 0.125, or 12.5p, which is the standard rate of electricity consumption according to OfGem at the time of writing. We then compared the annual cost to the annual level of consumption, which gave us a simple payback period. We then compared this simple payback period to the respective lease length, to give us a multi pronged approach to determining whether refitting the fluorescent fittings with LED is a worthwhile investment.

In order to quantify the energy saving potential of insulating the properties, we must consider the cost to install in relation to the overall energy bill for the property. Because specific information on each individual property isn't available, we must assign an assumed cost to each property, which we did based on the property size. For "Small" properties from 0-500 sqft, we assigned £1000 on the basis of OfGem's average cost for micro-businesses. For "Medium" Businesses of 500-1500 sq ft, we assigned £2000 on the basis of OfGems average cost for small businesses. For "Large" businesses measuring 1500-2500 sqft, we assigned £3000 on the basis of OfGems average consumption calculation for Medium businesses. Although the classifications between OfGem and my own research are different, I feel for the sake of the research Small, Medium and Large works better, but these classifications do line up to OfGems classifications. Payback potential is then calculated by comparing the investment value of the insulation upgrade in relation to the annual energy cost. The payback period is then compared to the lease length to see if the investment is worthwhile.

Research Findings

Portfolio Detail

Row Labels	Count of Class	Average of Lease (years)	Average of Net SqFt
Large	**1**	**5**	**2210**
20th Century Residential (Converted)	1	5	2210
Medium	**20**	**9.2**	**881.05**
19th Century Town	8	8.375	910.125
19th Century Village	2	10	758
20th Century Commercial	8	9	904.125
20th Century Residential (Converted)	1	10	552
21st Century Commercial	1	15	1039
Small	**10**	**7.3**	**318.5**
19th Century Town	4	4	354.5
19th Century Village	2	11	197.5
20th Century Commercial	2	10	334
20th Century Residential (Converted)	1	10	448
21st Century Commercial	1	5	256
Grand Total	**31**	**8.451612903**	**742.4516129**

Figure 7: Building types, lease length and sqft

The portfolio ended up being stacked in favour of medium sized retail units. This is understandable due to the medium classification having a wider range (500-1500 sqft). The types of building which occurred the most were 19th Century Town and 20th Century Commercial. Only one large building formed part of the portfolio. This reflects the mix of properties in Buckinghamshire; historically the county has been developed in line with advancements in transportation. As a result the development and age of buildings reflects when the town or village became prominent in terms of tending to horses and wagons; as advancements in wheels and carriages were made, coaches could travel further, and therefore other towns were developed. For example Amersham and Aylesbury lie on a key coaching route to Birmingham; Amersham's old town is more in keeping with the 19th Century Village style of construction, however Aylesbury is more akin to the 19th Century Town style of construction.

The average lease length was surprisingly long considering the modern retail environment. Research by EGI has shown lease lengths continue to contract, especially in the face of an uncertain retail environment in the UK. Across all sites, the average lease length was 8.45 years, compared to national norms of 3 or 5 years. However research in 2019 by Savills regarding commercial retail lease lengths in the UK found a different picture; averages of 3 to 5 years were common in shopping centres, however leases for high street units were usually 8-9 years. When comparing our data set to Savills research, considering our portfolio is stacked in favour of high street units, our data is on trend. This could be attributed to the small size of the businesses inhabiting the units, and the locations of the units. Very few of the locations in the portfolio were in prime locations perhaps making longer term leases more attractive to landlords. The average unit size was 742 square foot, which tells us more of our portfolio were towards the lower end of the scale between 0-2500 sq ft. Given the average square footage falls in the centre of the "Medium" bracket we have assigned to the portfolio, it is hardly surprising that the average is 742.

Lighting

Row Labels	Average of Number of Light Fittings	Average of Annual kWh usage (Flourescent)	Average of Annual Lighting Cost (Flourescent)
Large	**99**	**33105**	**£4,138.11**
20th Century Residential (Converted)	99	33105	£4,138.11
Medium	**40**	**13198**	**£1,649.72**
19th Century Town	41	13633	£1,704.16
19th Century Village	34	11355	£1,419.32
20th Century Commercial	41	13543	£1,692.93
20th Century Residential (Converted)	25	8269	£1,033.59
21st Century Commercial	47	15564	£1,945.48
Small	**14**	**4771**	**£596.38**
19th Century Town	16	5310	£663.78
19th Century Village	9	2958	£369.81
20th Century Commercial	15	5003	£625.40
20th Century Residential (Converted)	20	6711	£838.86
21st Century Commercial	12	3835	£479.35
Grand Total	**33**	**11122**	**£1,390.20**

Figure 8: Existing light fittings, energy consumption and annual cost to run

In terms of pre-existing light fittings, I calculated an average of 33 fittings per retail unit, on the basis of one fitting for every 2m2. The average electrical usage of these fittings per unit is 11122kWh per annum on the basis of 72w per fitting, with a high of 33105kWh for the largest unit in the portfolio. The average cost for fluorescent lighting in the portfolio is £1,309.20. The highest annual lighting cost is £4138.11, for the single property classified as large, over 1500 sqft. The difference between the average and highest cost can be explained by the higher number of small and medium sites bringing the average number of fittings per site, and therefore the overall consumption and cost down.

Row Labels	Average of Cost to swap to LED	Average of Annual kWh usage (LED)	Average of Annual Lighting Cost (LED)	Average of Annual Cost Difference	Average of Payback Period for LED Install
Large	**£1,989.00**	**16552**	**£2,069.06**	**£2,069.06**	**2.0**
20th Century Residential (Converted)	£1,989.00	16552	£2,069.06	£2,069.06	2.0
Medium	**£792.95**	**6599**	**£824.86**	**£824.86**	**2.0**
19th Century Town	£819.11	6817	£852.08	£852.08	2.0
19th Century Village	£682.20	5677	£709.66	£709.66	2.0
20th Century Commercial	£813.71	6772	£846.46	£846.46	2.0
20th Century Residential (Converted)	£496.80	4134	£516.80	£516.80	2.0
21st Century Commercial	£935.10	7782	£972.74	£972.74	2.0
Small	**£286.65**	**2386**	**£298.19**	**£298.19**	**2.0**
19th Century Town	£319.05	2655	£331.89	£331.89	2.0
19th Century Village	£177.75	1479	£184.90	£184.90	2.0
20th Century Commercial	£300.60	2502	£312.70	£312.70	2.0
20th Century Residential (Converted)	£403.20	3355	£419.43	£419.43	2.0
21st Century Commercial	£230.40	1917	£239.67	£239.67	2.0
Grand Total	**£668.21**	**5561**	**£695.10**	**£695.10**	**2.0**

Figure 9: LED Swap out costs and payback

The overall payback period for swapping to LED lighting was favourable in all instances apart from one erroneous site, which had a lease length of one year. The average payback period was 2 years or less. The average cost to upgrade a site to LED was just under £700, with a high of £2069 in the single property which fell into the large category. In addition to the significant cost saving, there would also be a large reduction in the carbon footprint generated by the store. LED installs are fairly straightforward, for small to medium businesses the entire shop could have their lights replaced in one night. For this reason I would suggest LED refits should be carried out for any business with a lease length longer than two years as the payback period would be sufficient to warrant the investment.

Insulation Upgrades

Row Labels	Average of Exisitng U Value of Building elements	Average of U Value of building elements post insulation works
19th Century Town	7.18	2.198
19th Century Village	7.18	2.198
20th Century Commercial	3.68	2.4
20th Century Residential (Converted)	3.68	2.4
21st Century Commercial	2.68	2.4
Grand Total	**5.421935484**	**2.295741935**

Figure 10: U Value Comparisons

For our insulation upgrades, our 19th Century Buildings had a starting U-Value of 7.18. Our 20th Century buildings had a starting U-Value of 3.68. As we can see from the table above, significant gains in U-Value for the entire property can be made by carrying out insulating works to the walls and replacing the glazed elements with double glazing. For the 19th Century buildings we see a drop of almost 5 points when comparing the existing install to the proposed installation, and a 1.2 drop for the 20th century buildings. For the two 21st Century commercial buildings in the portfolio, we saw an average drop of 0.28 in their U-Value. The lack of improvement compared to the 20th century and 21st century buildings is to be expected owing to our assumptions about the nature of the 21st century buildings construction.

Row Labels	Average of Cost to upgrade insulation	Average of Average Annual Cost (OfGem)	Average of Payback Period
19th Century Town	£3,793.88	£1,666.67	2.5
19th Century Village	£3,519.39	£1,500.00	2.6
20th Century Commercial	£1,355.53	£1,800.00	0.8
20th Century Residential (Converted)	£1,510.05	£2,000.00	0.8
21st Century Commercial	£0.00	£1,500.00	0.0
Grand Total	**£2,506.11**	**£1,709.68**	**1.6**

Figure 11: Costs to upgrade insulation

In terms of cost to upgrade the insulation, the average cost for our estate would be £2,506.11. Again we see a significant decrease in the cost to upgrade the unit in a 21st Century commercial environment, due to the assumed higher specification of construction in these units. We also see a significant difference between the 20th century and 19th Century buildings, again due to our preliminary assumptions about the thermal insulation and resistance of the respective property types. Surprisingly we see a higher average cost to insulate the 19th Century Town type of retail unit. This is likely due to inflation caused by a higher number of 19th Century Town properties.

As we can see from the table above, the average payback period for insulation upgrades is 1.6 years. The average payback period increases drastically for 19th century town and village properties to 2.5 and 2.6 years respectively. The payback period for 20th century commercial and converted residential properties is static at 0.8

On this basis, we can see that the payback period for installing cavity wall insulation or Kingspan insulating panels is favourable. Only one property of the 31 surveyed returned a negative result on the validity of installing insulation, however this single property had a lease length of only one year, and therefore is an erroneous bit of data.

In terms of reduction in CO_2 emissions, we will understandably see a drastic decrease in emissions. Using a calculation provided by the carbon trust, we will multiply the kWh of the respective lighting sources by the CO_2 Emission factor. The emission factor is a generalisation of emissions from all sources which provide electricity to UK properties; different energy sources, such as gas, coal or offshore wind, have different levels of CO_2 emissions. The emissions factor calculation serves to simplify our ability to tell how much CO_2 is released to power our properties.

Row Labels	Average of Annual CO2 Emissions (Flourescent) (kge)	Average of Annual CO2 Emissions (LED)
Large	**19525.94**	**9762.97**
20th Century Residential (Converted)	19525.94	9762.97
Medium	**7784.31**	**3892.16**
19th Century Town	8041.20	4020.60
19th Century Village	6697.13	3348.57
20th Century Commercial	7988.19	3994.09
20th Century Residential (Converted)	4877.07	2438.53
21st Century Commercial	9179.84	4589.92
Small	**2814.03**	**1407.02**
19th Century Town	3132.10	1566.05
19th Century Village	1744.97	872.48
20th Century Commercial	2950.98	1475.49
20th Century Residential (Converted)	3958.20	1979.10
21st Century Commercial	2261.83	1130.91
Grand Total	**6559.76**	**3279.88**

Figure 12: CO2 reduction from LED implementation

As we can see, on the basis of the calculation, the average annual CO_2 emissions following an LED upgrade in these properties is greatly reduced. In terms of sustainability, this is a clear additional benefit on top of the financial gains to be made by small to medium businesses.

Conclusion

In conclusion many small to medium independent retailers in the UK could benefit from minor retrofits to their lighting and insulation. The relative investment in lighting and insulation compared to the average lease lengths, annual rent, energy consumption and cost of energy consumption of the sample would be small in comparison to the savings, with the highest payback periods not exceeding 3 years which was significantly below the average lease length of almost 8 years. This proved the hypothesis that the payback for installing insulation and LED lighting is worthwhile. Even in instances where a full double glazed shopfront was required at a cost of £2500, the payback period still did not exceed the lease length.

The key implications of these findings are that there is potentially an untapped market for sustainable upgrades for small to medium independent businesses in the UK retail sector. As the government and indeed the world makes great strides towards reducing overall carbon emissions to slow and halt the (assumed) impact of human activity on global warming, it is important for us all to make whatever small steps we can to assist in this overarching goal. For small to medium businesses this may be easier than they think due to low cost and low payback periods for incredible reductions in electricity usage and improvement in thermal insulation.

Due to the low cost to implement insulation and LED lighting, and the government's increasing focus on policy supporting their sustainability goals, namely to be carbon neutral by 2050, it could be worth the government considering a subsidy for small to medium businesses to increase the amount of LED lighting and insulation used by them. In the past British Gas carried out a loft insulation programme, reducing the cost per roll for fibre wool loft insulation from £35 to £3 per roll for domestic users. A similar incentive could be used for commercial tenants. Alternatively retailers could receive financial assistance towards the cost of purchasing and installing lights and insulation, or perhaps a reduction in business rates to incentivise green retrofitting, if the purpose of the policy was to increase the overall number of businesses using LED and insulation.

The aims and objectives of the research have definitely been met. We identified a gap in research in terms of small to medium businesses and how widely sustainable technology was used. We identified two simple to install and low cost options for improving thermal insulation and lighting for small to medium businesses. We have assessed a portfolio of older building stock in the UK retail market in terms of it's insulation properties, and its lighting. We have identified the standard values for such buildings and made recommendations to upgrade them on the basis of assumptions given the age of the buildings, by conducting a desktop review of the buildings. Our findings show that green retrofitting using thermal insulation and LED lighting upgrades identified and suggested as part of the research are well worth the investment with very low payback periods in terms of the lease across the portfolio.

Limitations

The research conducted as part of this dissertation is relatively limited in scope, and barely scratches the surface of the subject of low cost green retrofitting. As it was not possible to visit each site in this portfolio specific data on conductivity, resistance and thermal properties could be ascertained. In order to pursue the research question further, site surveys would need to be conducted to fully check the properties of each building. If site specific surveys were conducted we could have used accurate measurements to determine the installation of Kingspan. Accurate measurements for walls and ceilings, across multiple floors, would have resulted in different results; the measurements used to calculate were very simple in this piece of research. With site specific surveys we could also accurately survey how many LED replacements were required and what type of LED's would be suitable; we have assumed a ceiling grid and 600x600 LED panel in this piece of research, however retailers often use lighting to showcase products, for example recessed ceiling spotlights. Another element to consider is accurate measurement of the U-Value of a building. In this piece of research we carried out a simple quantification by adding the various assets in situ together to give us a rough guide. A true U-Value measurement takes up to 10 days to complete as noted by OfGem; this simply was not feasible in the scope of this research, and certainly isn't even feasible for OfGem's energy assessors. However I would challenge the validity of conducting site specific surveys, as the intention was to create a model rather than a commercial proposal for green retrofits. The actual measurements of electrical usage and supply were not acquired in this research. Unfortunately this information was not available, and therefore assumptions were made to create our data model. EPC ratings for the buildings in question would have been useful to make a more accurate model. The EPC ratings would have given us information on how well the buildings perform already. Unfortunately the commercial EPC register has restricted access; you can only access the documentation for your store or building if you have the code provided by the EPC assessor.

Further Research

In terms of further research into the subject, there is a lot of information and a great push about sustainable technologies and practices given the current trend towards sustainability. Carrying out an in depth review of implementation of sustainable technologies in terms of green retrofit could widen the scope from insulation and lighting to water services, to emerging electrical technologies. Home or commercial battery packs, which store energy and release it as and when required are taking off throughout Europe. Including battery packs in small businesses may further improve the energy saving potential of a business. Furthermore, green energy generation and its use in retail could be investigated. Our entire mock portfolio were constructed outside of shopping centres, and therefore may have had scope for installation of solar panels. Regardless of implementing first hand energy generation in our portfolio, we could look further into ways to offset the carbon footprint of a business through pursuing green energy suppliers, which are increasing in size and influence in the 21st Century. Smart Meters are a current topic as well, and could also be implemented to further improve energy conservation. In all the topic of green retrofitting is current, and ought not be restricted to large retailers who have the economic backing to implement these cost and planet saving measures; sustainability ought to be accessible to all businesses if we are to help meet the national emissions targets.

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