Research Programme

Costing Energy Efficiency Improvements in Existing Commercial Buildings

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FULL REPORT

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This Programme supports the IPF's wider goals of enhancing the understanding and efficiency of property as an investment. The initiative provides the UK property investment market with the ability to deliver substantial, objective and high-quality analysis on a structured basis. It encourages the whole industry to engage with other financial markets, the wider business community and government on a range of complementary issues.

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Costing Energy Efficiency Improvements in Existing Commercial Buildings

Report

IPF Research Programme 2015–2018

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Costing Energy Efficiency Improvements in Existing Commercial Buildings

EXECUTIVE SUMMARY

The energy efficiency of commercial buildings is becoming an ever more important topic. From April 2018, the landlords of the more than 80,000 rental units with EPC ratings of F or G will need to review the opportunities to improve these assets when they are next let (or by 2023).

This study updates the Investment Property Forum's previous work on the costs and savings from energy efficiency measures in existing buildings. It draws on fresh cost and energy data, together with additional analysis addressing both minimum energy efficiency standards (MEES) regulations and longer term carbon reduction targets for 2030.

Six building archetypes (four offices, a retail warehouse and an industrial building) were studied and a range of discrete and combined packages of improvement measures were assessed for their impact on EPC ratings, energy use, carbon emissions and cost (capital and lifecycle).

Key findings include:

- In all buildings it was possible to identify some measures that meet the MEES regulations' cost effectiveness test and improve the rating of the building to an E rating or above. For most buildings these measures cost from £10 to £20 per square metre.
- Replacement of older, less efficient lights (e.g. T8 compact fluorescent tubes) with more efficient versions within the same luminaire is a highly cost effective way of both improving EPC rating and saving money. The IRR from such measures is typically at least 20%.
- For older buildings with inefficient boilers there is a benefit in installing a more efficient version. However, consideration should be given to using an air source heat pump (ASHP), where appropriate. The reduction in carbon emissions and income from the Renewable Heat Incentive (if the heat pump is used for heating only) make the return on this investment comparable to installing a new boiler, but with far larger long-term carbon savings.
- For air-conditioned buildings with double glazing, there is very limited benefit from installing higher performance glazing as the saving in heating demand is more than offset by additional cooling requirements.
- Where older fan coil units are present in a building, their refurbishment to use modern Electronic Commutation (EC) drive units will result in significant energy savings and a strong return on investment.
- There are fewer opportunities for cost effective improvements in more modern buildings, but, typically, lighting and EC drive upgrades deliver good returns, even in buildings under 10 years old.
- In most buildings the viable improvement opportunities are from services improvements. However, where the base building fabric is very poor (as in the case of the Industrial Building considered in this study) it is necessary to address this if a reasonable EPC rating is to be achieved. Therefore, whilst services are both the easier and less costly route to energy efficiency, there are limits to this where the building is lacking basic insulation.
- The projected decarbonisation of the electricity grid means that it will become ever more important to reduce demand for heat in buildings or to supply this heat via low carbon sources (e.g. heat pumps). Meeting the UK's carbon reduction objectives set out by the Climate Change Act (2008) requires a c.50% reduction in direct (i.e. natural gas or other fossil fuel) carbon emissions from non-domestic buildings by 2030. This level of saving is achievable for each of the buildings covered in this study, but requires investment in new heating plant and basic energy efficiency, as well as in more immediately attractive measures, such as new lights.

1. INTRODUCTION

Since the Investment Property Forum's (IPF) 2012 research into improving the energy efficiency of existing commercial buildings, there has been substantial regulatory and technological change. Most notable among these is the introduction of minimum energy efficiency standards (MEES) for leased property[1], which comes into force in April 2018. Other changes include amendments to Building Regulations, changed or new incentives for generating renewable electricity and heat and the increasing use of LEDs (light-emitting diodes), a technology that was just emerging for mainstream lighting in 2012.

The above changes, together with the importance of providing current information to the industry, have prompted an update and expansion of the previous analysis. The aim is still to help investors and asset managers take steps to manage risk, reduce running costs and improve the long-term carbon performance of their buildings.

This study considers the scale of investment and associated operational energy savings from implementing energy efficiency measures in existing buildings. These include individual improvements and packages of measures that reflect both 'market standard' and more energy efficient investments. The study does not consider new construction, major redevelopment (i.e. where the building is striped back to its frame) or changes of use.

As well as updating previous analysis, this report includes new information, including:

- Absolute costs of implementing different options as well as the variation between the costs of more or less energy efficient options. This is because the introduction of MEES regulations means that landlords may be obliged to implement cost effective energy efficiency measures even if they would not otherwise have invested in their property;
- An indication of the range of performance that may occur in practice, as well as that estimated using the calculations used to produce an Energy Performance Certificate (EPC);
- Distribution of costs and savings between landlord- and occupier-controlled areas; and
- Implications for decision making of projected changes in the carbon emissions and cost of each unit of supplied gas or electricity.

This report is accompanied by an Excel spreadsheet that contains the key data tables underpinning the analysis. These can be used to analyse results for a specific building and/or technology option. As with any study of this sort, care is needed before applying the indicative benchmarks to a specific building.

The characteristics of the buildings assessed in this research are described in Table 1.1, together with an indicative (but not actual) image. These buildings are broadly consistent with those assessed in 2012, albeit remodelled using the current version of the National Calculation Method (NCM). Office One has been altered slightly so as to create a starting EPC of F (rather than E previously).

[1] Through the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015 and the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016.

1. INTRODUCTION

Table 1.1: Building models

Office One

Reflects London Mid Town and West End offices which are predominantly period, dating from pre-1940. Heating system only.	
Services	Heating only
Plan depth	Narrow
Age	Pre 1940's
Glazing % and type	50% single

Office Two

Partly glazed air-conditioned early 1990s narrow plan office. Compliant with 1990 Part L Building Regulations.	
Services	Air-conditioned
Plan depth	Narrow
Age	Pre 1995
Glazing % and type	50% double

Office Three

Highly glazed deep plan air-conditioned office. Compliant with 2002 Part L Building Regulations.	
Services	Air-conditioned
Plan depth	Deep
Age	Post 2002
Glazing % and type	80% double

Office Four

As Office 3 but compliant with 2006 Part L Building Regulations.	
Services	Air-conditioned
Plan depth	Deep
Age	Post 2006
Glazing % and type	80% double

1. INTRODUCTION

Table 1.1: Building models

Retail warehouse

Single storey with lighting, heating and air conditioning. Limited windows. Office and warehouse space included. Compliant with 1990 Building Regulations.	
Services	Air-conditioned
Plan depth	Deep
Age	Post 2006
Glazing % and type	10% double

Industrial / storage warehouse

Single storey with lighting and heating. Limited windows or roof lights. Offices included. Compliant with 1990 Part L Building Regulations.	
Services	Heating only
Plan depth	Deep
Age	Pre-1995
Glazing % and type	10% single

It is important to remember that the modelled buildings are representations of the existing stock that might be owned by property investors and are not case studies of actual buildings.

Subsequent sections of this report address:

- The importance of energy efficiency for commercial landlords – summarising the key regulatory, financial and market drivers for energy efficiency;
- Energy, carbon and commercial buildings – current data on, and UK objectives for, the energy and carbon performance of commercial buildings;
- Improving energy efficiency – summarises the opportunities for landlords and their occupiers reduce energy consumption;
- Findings – including information on impact of different asset upgrades for each reference building on capital and lifecycle costs, carbon emissions and EPC rating; and
- Taking action – some key conclusions and recommendations arising from the analysis.

Core data underpinning this research may be downloaded from the Resource Library on the IPF website (www.ipf.org.uk/costsofenergyefficiency).

2. THE IMPORTANCE OF ENERGY EFFICIENCY FOR COMMERCIAL LANDLORDS

The implementation of regulations imposing MEES for privately leased buildings in both Scotland and England and Wales[1], is arguably the most powerful stimulus for energy efficiency to affect previously disinterested landlords. However, there are many other regulatory and market factors that make energy efficiency an important issue for commercial property, Landlords should take all suitable opportunities, therefore, to improve the efficiency of their estates while working with their occupiers to achieve energy savings wherever possible.

Appendix A provides a glossary of the current regulatory framework and other factors influencing energy use in existing buildings; some of the most significant recent developments are described below.

2.1 Regulations

Minimum energy efficiency standards

MEES regulations place obligations on landlords to take reasonable and cost effective steps to improve the energy efficiency of buildings with sub-standard energy ratings. The regulations apply to all buildings requiring an Energy Performance Certificate (EPC) under the Energy Performance of Buildings Regulations where that certificate is F or G. The regulations affect new leases and lease renewals from 2018 and will apply to all existing leases, where a current EPC is in place, from 2023.

Landlords are required to make improvements to all sub-standard properties unless they meet the required criteria for an exemption. These criteria include:

- inability to secure necessary consents from a key stakeholder e.g. a planning authority, superior landlord or the occupier;
- demonstrable impact on the quality of the property or a loss in value of more than 5% (for example, where insulation could affect the integrity of the building structure or result in a significant loss in lettable floor area); and
- evidence, including quotes from installers, that show the measure is not cost effective (see below).

Improvements are deemed cost effective if the value of the energy saved over seven years is greater than the cost of the works (plus interest at the Bank of England's base rate). The cost effectiveness test has no link to the affordability of these investments for the landlord or whether occupiers are willing to make any contribution to the costs. The obligation falls entirely on the landlord who must seek consent, rather than financial contributions, from the occupier to make sufficient cost effective improvements to achieve the minimum rating or until there are no further cost effective works.

Suitable improvement measures are those listed in Table 6 of Building Regulations Part L2b (see Table 2.1). These measures have been used as a reference point for the improvement options considered in this report.

[1] Through the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015 and the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016.

2. THE IMPORTANCE OF ENERGY EFFICIENCY FOR COMMERCIAL LANDLORDS

Table 2.1: Improvement options for complying with MEES in England and Wales

No.	Improvement measure
1	Upgrading heating systems more than 15 years old by the provision of new plant or improved controls.
2	Upgrading cooling systems more than 15 years old by the provision of new plant or improved controls.
3	Upgrading air-handling systems more than 15 years old by the provision of new plant or improved controls.
4	Upgrading general lighting systems that have an average lamp efficacy of less than 40 lamp-lumens per circuit watt and that serve areas greater than 100m^2 by the provision of new luminaires or improved controls.
5	Installing energy metering following the guidance given in CIBSE TM39.
6	Upgrading thermal elements which have U-values worse than those set out in Approved Document Part L2b.
7	Replacing existing windows, roof windows or roof lights (but excluding display windows) or doors (but excluding high-usage entrance doors) which have a U-value worse than 3.3 W/m^2.K.
8	Increasing the on-site low and zero (LZC) energy-generating systems if the existing on-site systems provide less than 10% of on-site energy demand, provided the increase would achieve a simple payback of seven years or less.
9	Measures specified in the Recommendations Report produced in parallel with a valid Energy Performance Certificate.

In some cases, occupiers, who will benefit through reduced energy consumption, might be prepared to contribute to improvement costs. However, this is likely to be determined by the quality of the landlord – occupier relationship, local market conditions and the ability of the landlord to provide convincing evidence that the occupier will actually see the projected energy savings.

Improving F- or G-rated buildings is likely to be just the start of efforts to mandate the improvement of existing buildings to help achieve the UK's long-term national energy and carbon targets. The England and Wales regulations are scheduled to be reviewed in 2020 and it is possible that the minimum standard will be raised as a result.

Further information on the application of MEES in England and Wales is available in the 2017 Government Guidance[2].

In Scotland, landlords of leased buildings over 1,000m^2 that do not meet the standards of the 2002 building regulations are required to produce an Action Plan for improving the property at the time of sale or lease to a new occupier. The Action Plan should cover seven improvement areas where they are relevant to the building including replacing incandescent lighting, improving lighting and heating controls, replacing boilers that are more than 15 years old, insulating accessible loft spaces and hot water storage and installing draft exclusion around doors and windows. Landlords have 3.5 years to make the improvements set out in the Action Plan, but, alternatively, can opt to publish a Display Energy Certificate each year, detailing the property's actual operational energy use.

[2] https://www.gov.uk/government/publications/the-non-domestic-private-rented-property-minimum-standard-landlord-guidance

2. THE IMPORTANCE OF ENERGY EFFICIENCY FOR COMMERCIAL LANDLORDS

Other regulations

Beyond MEES requirements, existing buildings are required to comply with Building Regulations that specify minimum performance standards for installation of new services or fabric elements and also specify the need for 'consequential improvements' to a building when extending, installing new services or increasing the capacity of existing services. Consequential improvements do not apply when replacing existing services.

Landlords are also under a range of obligations in respect of their buildings, including inspections of air conditioning equipment; however, these obligations do not impose requirements that would necessitate plant replacement or other works.

Larger landlords and occupiers (i.e. those listed on the FTSE) are obliged to report on the carbon emissions associated with their activities, this would include direct and indirect (i.e. electrical) emissions from their buildings. Whilst not mandating any specific action, this is one of several forms of information disclosure that make it more important for listed landlords to reduce their energy consumption and for major occupiers to be more selective about the energy performance of the spaces they occupy.

2.2 Levies and Incentives

From 2019, a simplification of the business energy tax regime means that the CRC Energy Efficiency Scheme is being withdrawn and the existing Climate Change Levy is being increased commensurately to 0.85p per kWh for electricity and 0.34p per kWh for gas. Importantly, the future rates for the Climate Change Levy will increase more significantly for gas consumption than for electricity use. The aim is to encourage users to move towards the increasingly lower carbon electricity as a source of energy (e.g. via heat pumps) rather than gas and thereby increasing the use of a lower carbon energy source.

Set against the energy tax is a series of incentive mechanisms to encourage the adoption of energy efficient and low carbon technologies. These include:

- Feed-in tariff (FiT) for generation of renewable electricity – this is an inflation-linked incentive per unit of renewable energy generated. The amount of the tariff varies according to the technology, size and, for building integrated renewables, the base level of energy efficiency in the building. Current tariff levels for Photovoltaics are shown in Table 2.2 and are subject to regular review, reducing in line with the reducing costs of the technologies they incentivise.
- Renewable heat incentive (RHI) – this incentivises the generation of renewable heat through, for example, the use of ground or air source heat pumps (GSHP or ASHP), biomass boilers or solar thermal collectors. Current tariff levels for ASHP are shown in Table 2.2. As with the feed-in tariff, rates are linked to the energy efficiency rating of the building in which the technology is installed. For ASHP, the incentive is limited to systems capable of heating only.
- Enhanced capital allowances – for products listed on the energy technology list (https://etl.beis.gov.uk/), tax paying purchasers are eligible for a 100% first year allowance on the full cost of the asset. This enhanced allowance brings forward the tax allowances available for the asset, giving a cash flow benefit to the purchaser, in comparison to a less efficient technology for which only a proportion of its value would be eligible for capital allowances that would accrue each year as it depreciated. Not all landlords will pay tax, e.g. Real Estate Investment Trusts (REITs) do not typically pay corporation tax and so will not benefit from enhanced capital allowances.

2. THE IMPORTANCE OF ENERGY EFFICIENCY FOR COMMERCIAL LANDLORDS

Rates and eligibility criteria for levies and incentives change frequently, so it is important to check availability if they are an important influence on decision making.

Table 2.2: Current rates for Feed-in Tariff and Renewable Heat Incentive

Tariff type	Current tariff (pence per kWh output)
Feed-in tariff	
PV installations between 10 and 50 kWp	
Fewer than 10 installations, in buildings with EPC of D or above	4.29
More than 10 installations in building with EPC of D or above	3.86
Installation in building with EPC of below D.	0.43
Renewable heat incentive	
Air Source Heat Pump (used for heating only)	2.61

2.3 Market factors

The importance of energy performance varies across the different markets that encompass commercial buildings. However, for institutional investors there are several factors increasing the importance of both the actual energy use and asset rating of commercial buildings.

MEES side effects

The impact of MEES is likely to extend beyond basic regulatory compliance. Increased industry awareness and due diligence may make it more difficult to market a building with a 'sub-standard' EPC. Even if an asset is technically compliant with the regulations, because improvement measures do not pass a cost effectiveness test, the landlord and their agent will be exposed to questions about the quality of the product offered. These concerns may be reduced if the building is already deemed a 'lower value' property, but could be considerable if the building is otherwise of a reasonably high standard. Where there are other better rated, but otherwise comparable, properties in the local area, landlords may feel obliged to improve the building's rating to reduce the risk of a reduction in market value.

A further MEES-related issue, that would be an aggravation or risk to a potential purchaser, is that any exemption claimed on the grounds of cost effectiveness is only valid for five years. This means that the landlord has the administrative burden of ensuring exemptions are kept valid or may even find that they are liable to incur improvement costs should future re-evaluation of the property identify measures that pass the cost effectiveness test.

Reporting and benchmarking

More and more institutional investors and property companies are participating in sector benchmarking initiatives or other forms of reporting on their assets performance. Perhaps the most widely known performance benchmark is GRESB (the Global Real Estate Sustainability Benchmark), now used by around 750 global property entities, accounting for $2.8 trillion of asset value, to report their performance. GRESB poses a series of detailed questions about sustainability performance, including those on energy use, carbon emissions and average EPC rating. Accordingly, investors and asset managers, wanting to score highly on these metrics, will need to be able to demonstrate ongoing improvements in their portfolio's performance.

2. THE IMPORTANCE OF ENERGY EFFICIENCY FOR COMMERCIAL LANDLORDS

In addition to regulatory reporting requirements, the property industry also assesses the quality of information disclosed in corporate reporting on sustainability topics. The European Public Real Estate Association (EPRA) published Sustainability Best Practice Recommendations that are used to review the content of member reports. Within these recommendations c.30% of the assessment is based on energy and carbon emissions.

Green bonds

Real estate is financed through many forms; a relatively new but rapidly growing option is through the issuance of green bonds. Money raised through the sale of green bonds is explicitly linked to the delivery of environmental or social objectives. The International Capital Markets Association has established Green Bond Principles to underpin quality in the market and other related activities, such as the Climate Bonds Initiative and rating methods published by Moody's and Standard and Poor's are helping to grow the market for assured impact products.

In 2016, over $80 billion of green bonds were issued, nearly double those of the previous year[3]. Around 18% of these bonds were used to finance investment in buildings and industry. Although the market continues to grow rapidly, demand is currently in excess of supply, resulting in tight pricing that in some (but not all) studies indicates a lower cost of capital to the issuer.

Occupier expectations

More occupiers are now reporting on the environmental impacts of their businesses, either as a result of compulsory reporting requirements or to demonstrate effective management of their wider business impacts and responsibilities. In addition, occupiers are becoming more aware of the impact of working environment's on the wellbeing of their staff and other visitors. Considerations such as the quality of lighting or ventilation are therefore becoming more relevant to their decision making as the performance these systems have an important influence on the quality of the internal environment. The impacts of poor equipment may be far greater, therefore, than the costs of the additional energy consumption.

Thus, while occupiers may not be willing to pay more rent for energy efficient buildings, they are likely to prefer this space and are now increasingly able to identify its characteristics. When the market is buoyant and/or if there is limited local competition then this may not impact on rental or asset values but during inevitable periods of softer market conditions, and particularly in areas where there are a lot of otherwise comparable properties, there is the risk that poorly performing buildings will see their desirability and, therefore, value diminish.

[3] Climate Bonds Initiative, 2016. Green bonds highlights 2016.

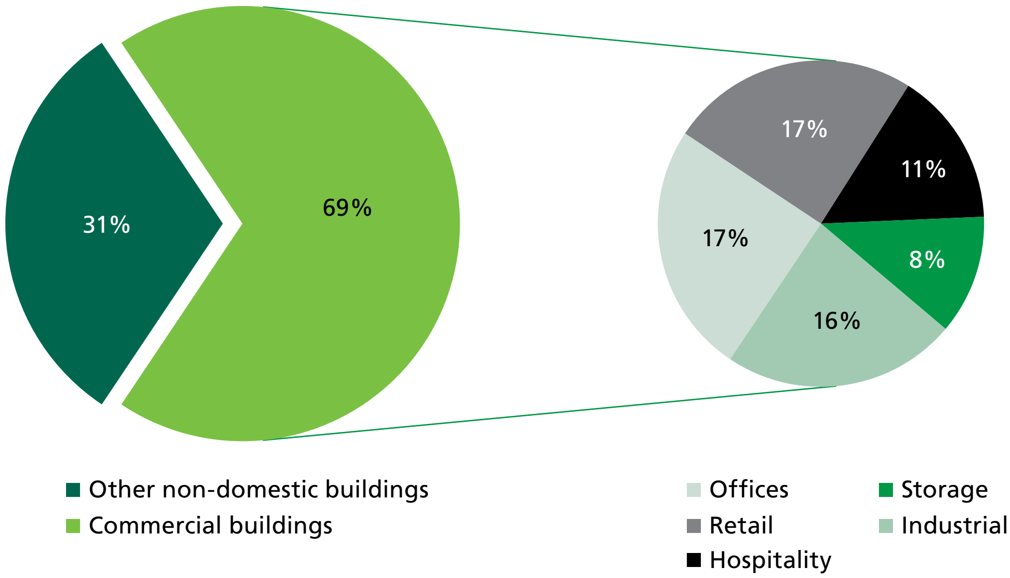
3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

Commercial buildings use 111 Terra Watt hours (TWh) or 111 billion kWh of energy each year and are responsible for the emission of 40 million tonnes of carbon dioxide equivalent (CO_2e) greenhouse gases, representing 8% of the UK total.

3.1 Energy Use in Commercial Buildings

Commercial buildings are responsible for approximately 70% of the energy used by non-domestic buildings (see Figure 3.1), totalling around 111 TWh in the year 2014-15[4]. In offices and retail buildings, energy use is dominated by electricity consumption whereas, for other building types, the balance is more even or with greater use of other energy sources – primarily gas for heating (see Figure 3.2).

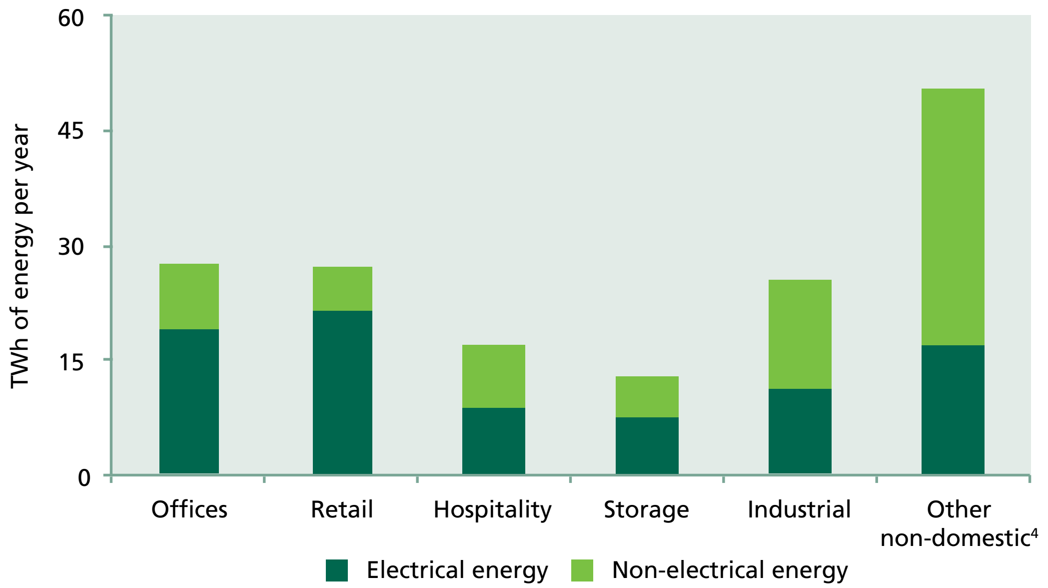
Figure 3.1: Energy consumption of non-domestic buildings



Source: Department for Business, Energy and Industrial Strategy (BEIS), Building Energy Efficiency Survey 2016.

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

Figure 3.2: Electrical and non-electrical energy consumption in commercial buildings



Source: BEIS, 2016. Building Energy Efficiency Survey 2014-2015.

The main energy uses within commercial buildings are:

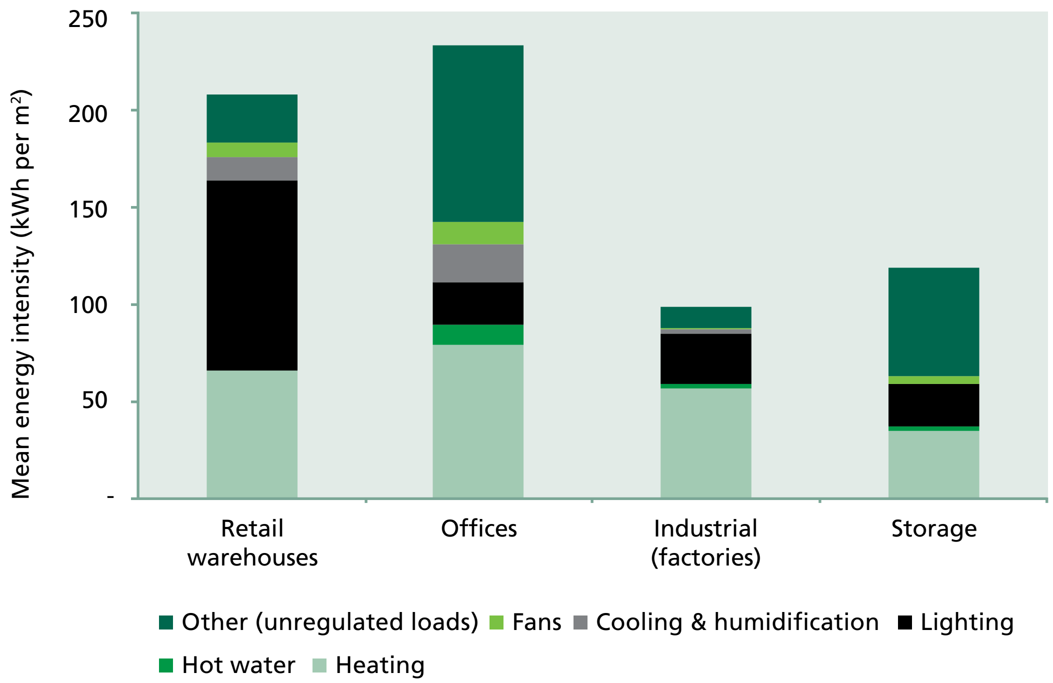
- Lighting;
- Heating;
- Ventilation and air conditioning (including fans, pumps and chillers);
- Power for IT and other equipment;
- Hot water for washing, showers and catering;
- Chilled storage (some retail and industrial buildings); and
- Other uses, such as lifts.

The importance of the above uses varies significantly between and within building types. Mean consumption in different commercial building types is shown in Figure 3.3, with regulated energy consumption (i.e. that covered by Building Regulations and used to determine Energy Performance Certificates) varying shades of red and unregulated energy in green. In all building types, heating and lighting are a prime sources of energy consumption, with cooling, ventilation and ICT also being important in offices, whilst cold storage facilities are important in overall warehouse and retail energy use.

[4] Other non-domestic buildings include hospitals, schools, universities and other public buildings.

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

Figure 3.3: Mean energy uses in commercial buildings



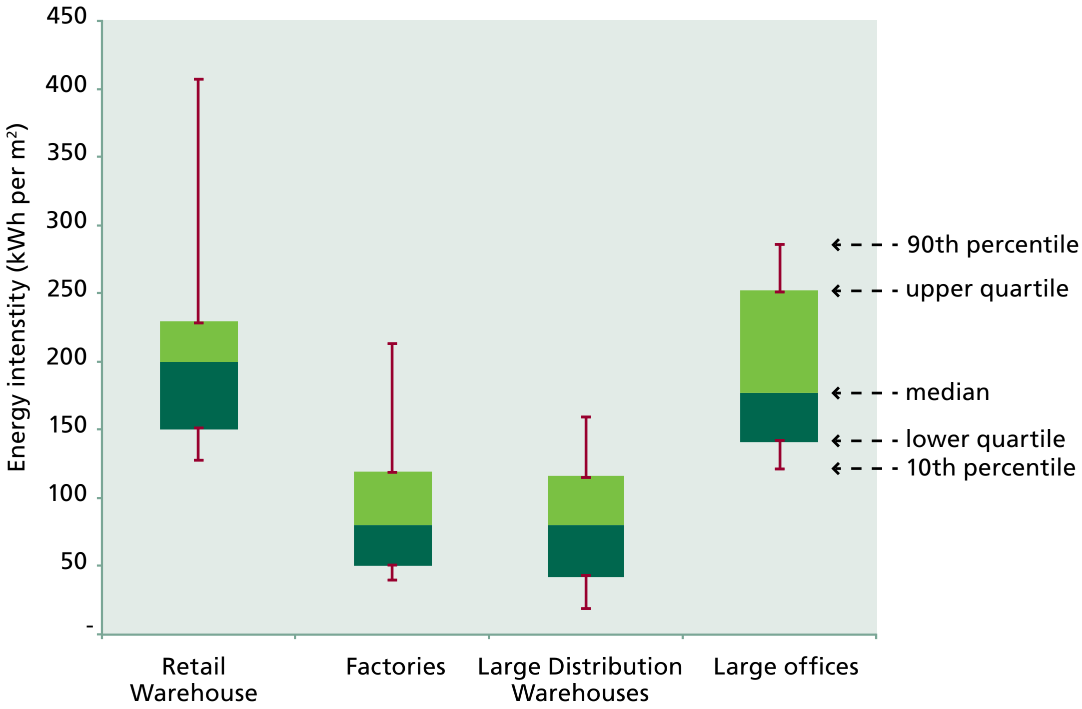
Source: BEIS, 2016. Building Energy Efficiency Survey 2014-2015.

It is important to remember that there is substantial variation in both the scale and composition of energy use within each building type. In offices, for example, many air-conditioned buildings use more energy for cooling than heating. Figure 3.4 indicates the levels of variation in energy around the median for different building types covered by the Building Energy Efficiency Survey[5].

[5] Department for Business, Energy and Industrial Strategy, 2016.Building Energy Efficiency Survey.

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

Figure 3.4: Variation in energy consumption



Source: BEIS, 2016. Building Energy Efficiency Survey 2014-2015.

3.2 Predicting Energy Consumption

Energy consumption is affected by a complex interaction of factors, including:

- Geographical location (yearly temperatures and sunlight patterns);
- Orientation;
- Height, shape and form;
- Proximity of other buildings;
- Building fabric thermal performance;
- Internal temperatures;
- Occupancy density;
- IT equipment (density and efficiency);
- Hours of operation;
- Energy efficiency of the building services – heating lighting, mechanical ventilation and cooling (if present) and hot water systems; and
- Operation of the building services (including maintenance).

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

A building's energy use can be estimated using theoretical models or, if available, from analysis of actual consumption data. Theoretical models, such as those used to produce an Energy Performance Certificate (EPC)[5], typically provide an assessment of the asset's performance under a standardised use scenario and are helpful in assessing the potential energy efficiency of the building. However, such models do not provide a complete indication of the actual energy use in the building because they only assess regulated emissions (e.g. heating, lighting, cooling, and ventilation), making no allowance for variations in occupation, hours of use or the effectiveness of the building's management regime.

Research by the Better Buildings Partnership[6] highlights the inconsistency within an EPC rating of a building's actual energy consumption, including an illustration of an E-rated building that is 66% more energy efficient than a B-rated building.

Although the energy consumption of some buildings with higher EPC ratings is greater than for those deemed to be less efficient, this may not be the result of a failing in the assessment method. For example, discounting errors in the assessment process[7], performance differences could be a result of varying densities of occupation, the presence of a significant level of unregulated energy consumption (in the form of IT rooms or catering facilities, say) or poor energy management.

Energy models can still be used to assess the scale of reduction in regulated energy that might arise in a building where the use pattern is unchanged. Calibration of the theoretical model, to include variations in hours of occupation and varying levels of commissioning and management, can be used to assess the spread of potential energy impacts associated with any given measure. Research by Carbon Buzz[8] has shown that for offices reporting design and actual energy data into their portal, the mean actual energy data was 1.59 (for heat) and 1.71 (for electricity) times higher than the mean modelled consumption estimates. Interestingly, the analysis did not identify a marked difference in the performance gap arising from the use of different modelling tools.

3.3 Carbon

Commercial buildings are responsible for around 8% of UK greenhouse gas emissions[9], almost entirely as a result of energy consumption. Of the 40 million tonnes CO_2e of building-related emissions in 2015, around a third (c.13Mt CO_2e) are direct emissions, related to the use of fuels (predominantly natural gas) for heating, with the balance (c.27Mt CO_2e) resulting from the consumption of grid electricity.

Since 2000, CO_2e emissions from commercial buildings have fallen, but this is almost exclusively as a result of reduced carbon emissions associated with supplied electricity. The level of energy consumption is largely unchanged, with only a 4% reduction in energy use per m^2 of floor area[9].

[5] These might include the Simplified Building Energy Model (SBEM) or a Dynamic Simulation Model, both of which would be set up with National Calculation Method assumptions about occupancy patterns and densities.
[6] Better Buildings Partnership, 2012. A tale of two buildings: Are EPCs a true indicator of energy efficiency? www.betterbuildingspartnership.co.uk
[7] It is not unusual to find that EPC assessments where the default assumptions have been used for all the building services and fabric performance standards. It would not be surprising in these instances that the resulting model does not reflect the building's actual performance.
[8] Carbon Buzz, 2013. Summary of audits performed on Carbon Buzz by the UCL Energy Institute.
[9] Committee on Climate Change, 2016. Meeting Carbon Budgets: 2016 Progress Report to Parliament. www.theccc.org.uk

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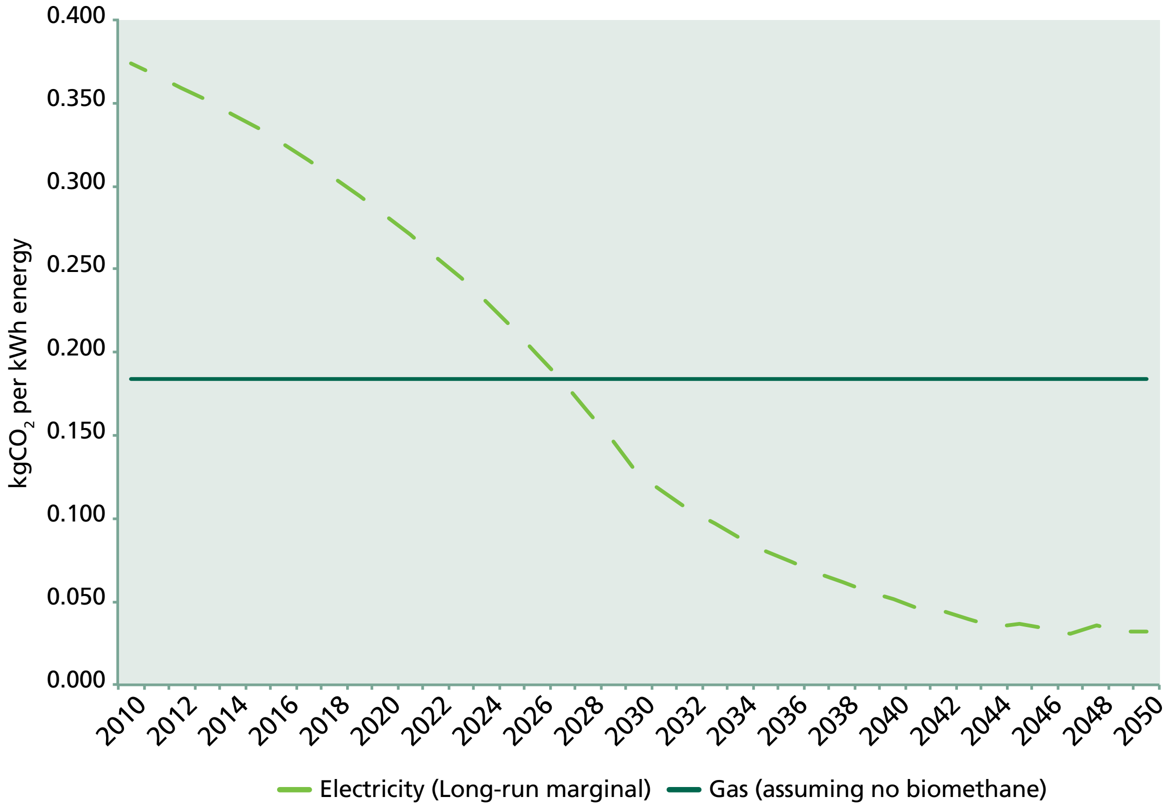
The impact of grid decarbonisation

The split between direct and indirect emissions (i.e. those linked to electricity consumption) is important. The carbon impact of electricity consumption has changed markedly in recent years due to the increased use of gas and renewable energies for generating grid electricity. The CO_2e emissions linked to the generation of each kWh of grid electricity declined by around 45% between 2010 and 2017. As a result, the marginal emission factor (i.e. the factor used to calculate carbon savings from reducing grid energy consumption) has reduced by 16%, from approximately 0.37 kgCO_2e per kWh to 0.31 kgCO_2e per kWh[10]. This marginal emission factor is projected to reduce further in the coming decades (see Figure 3.5), to below 0.13 kgCO_2e per kWh in 2030 – a 70% fall on 2010 levels.

Figure 3.5: Projected marginal carbon intensity of energy

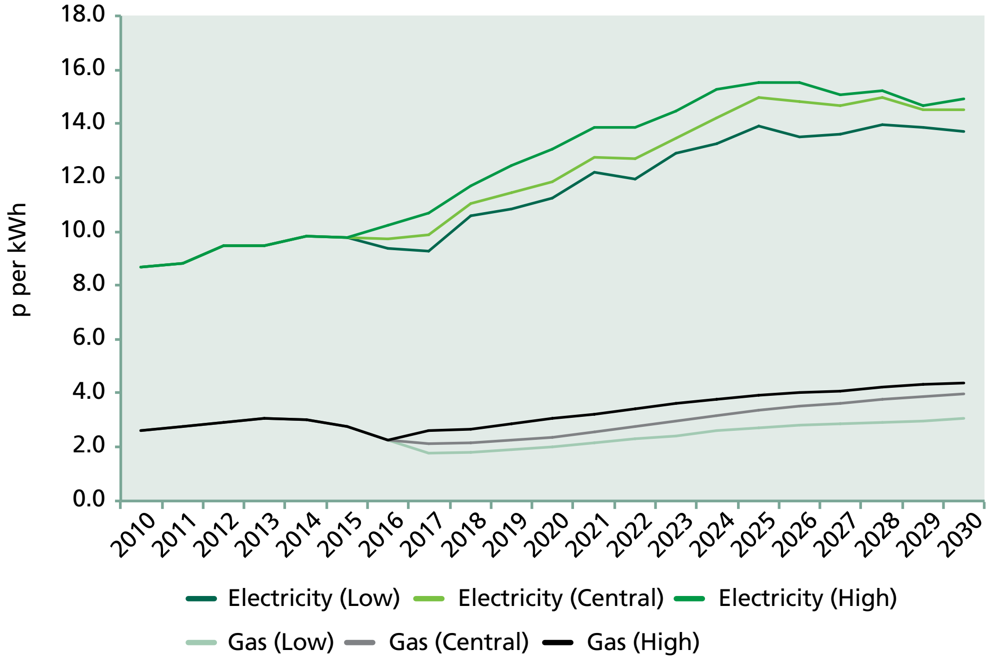


The anticipated further decarbonisation of the electricity grid means that emissions from commercial buildings should reduce in the future. However, this is no cause for complacency for two important reasons. Firstly, the ability to decarbonise in line with the Government's projection relies on the UK becoming more energy efficient. Without energy efficiencies across the economy, the additional demand will make it more difficult to generate sufficient low carbon electricity. Secondly, the investment needed to decarbonise the grid is likely to result in the cost of supplied electricity increasing in the future (see Figure 3.6), with commercial electricity prices expected to be c. £0.15 per kWh in 2025 (in 2017 prices). As a result, while electricity use may have lower carbon emissions it is likely to become around 55% more expensive.

[10] BEIS, 2016. Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions. Interdepartmental Analysts Group.

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

Figure 3.6: Projected costs of commercial and industrial energy supply to 2030



Source: BEIS, 2016.

Emission reduction trajectory

The Climate Change Act (2008) commits the UK Government to reducing greenhouse gas emissions by 80% compared to 1990 levels by 2050. The Act also establishes legally binding carbon budgets which specify the level of carbon emissions over a five-year period. These budgets are designed to represent the most economically effective means of reducing carbon emissions so as to achieve the longer term 2050 target. Carbon budgets have been established until 2032 and these are considered to be consistent with the UK's commitment under the Paris Agreement (COP21), although there may need to be further tightening of ambition in the future. Carbon budgets to 2032 and associated percentage reduction on 1990 emission levels are shown in Table 3.1. In 2015, UK emissions were 38% below 1990 levels (i.e. already at the level projected for the third carbon budget); however, with current policies and rate of progress, the fourth budget will not be achieved.

Table 3.1: Carbon budgets to 2032

Budget period	Greenhouse Gas Emissions ($MtCO_2e$)	Reduction on 1990 emission levels (%)
1st carbon budget (2008 to 2012)	3,018	23%
2nd carbon budget (2013 to 2017)	2,782	29%
3rd carbon budget (2018 to 2022)	2,544	35% by 2020
4th carbon budget (2023 to 2027)	1,950	50% by 2025
5th carbon budget (2028 to 2032)	1,765	57% by 2030

3. ENERGY, CARBON AND COMMERCIAL BUILDINGS

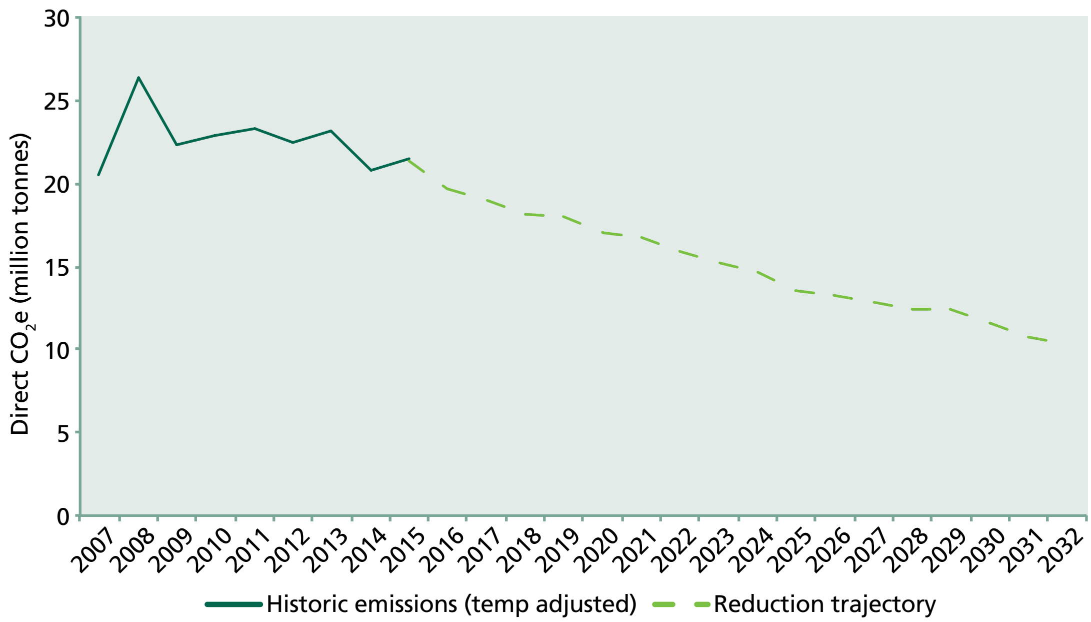
The most recent report tracking UK performance against current and future carbon budgets raises major concerns about progress in the non-residential buildings sector.

"What is clear is that the current policy framework is not generating sustained emission reductions and that a transformational change is needed for non-residential buildings to make the necessary contribution to meeting future carbon budgets." (Committee on Climate Change, 2016).

The key requirement is for non-domestic buildings to reduce their direct emissions from on-site use of fossil fuels for heating, whilst also achieving efficiencies in electricity use to minimise the additional load on the electricity system associated with a move to electrification of heating.

An emissions reduction trajectory for direct (i.e. non-electricity) carbon emission from non-residential buildings has been established (see Figure 3.7), which targets a 29% reduction on 2007 levels by 2027 and proposes that direct emissions are 50% below 2007 levels by 2032.

Figure 3.7: Direct carbon emission reduction trajectory for non-residential buildings



Source: Committee on Climate Change, 2016.

To help in decarbonisation of the electricity grid, non-residential buildings should also be aiming to achieve a small (c.3%) reduction in electricity use. At first sight, this does not appear to be a challenging target but, importantly, much of the reduction in direct carbon emissions is likely to be achieved through the adoption of electric heating options (e.g. heat pumps), so even achieving a slight reduction as a sector will be difficult without substantial efficiencies to offset the additional heating load.

4. IMPROVING ENERGY EFFICIENCY

The priorities for reducing energy use in an existing building depend on how energy is consumed within it. In most buildings, the majority of landlord-influenced energy consumption is linked to:

- Heating and hot water;
- Fans, pumps and controls associated primarily with the air conditioning system;
- Lighting; and
- Cooling (and humidification).

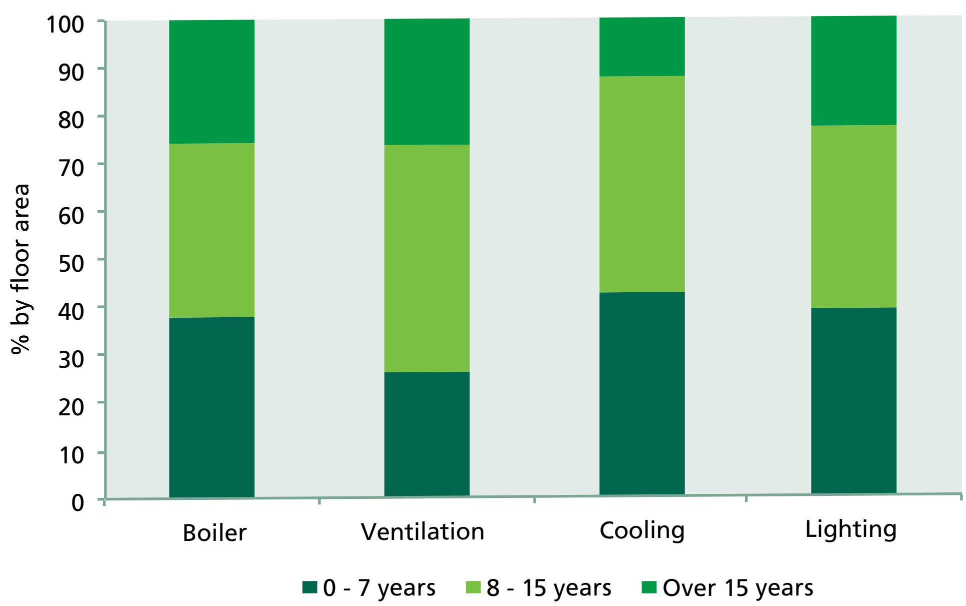
Whilst heating is important in most building types, the relative significance of cooling and lighting can vary considerably.

4.1 Impact of Refurbishment

Typically, the most rapid and cost effective means of reducing energy use and associated carbon emissions is to implement an active energy management regime with close control of the settings, run time and condition of key services. Installation of effective metering systems to enable the performance and consumption of key areas/plant to be monitored is an important first step in understanding energy use and enabling it to be more effectively managed and reduced.

Notwithstanding the above, where existing plant are aged and inefficient compared to current systems, refurbishment, even to a 'market standard[11]', specification would naturally reduce operational energy use and CO_2e emissions. Figure 4.1 draws on the 2016 UK Building Energy Efficiency Survey to show that, whilst many buildings have relatively modern services, around a quarter of the over 3,500 properties surveyed had boilers, ventilation and/or lighting systems that were over 15 years old.

Figure 4.1: Age banding of key building services in UK non-domestic buildings



Source: Department for Business, Energy and Industrial Strategy, 2016.Building Energy Efficiency Survey.

4. IMPROVING ENERGY EFFICIENCY

The following illustrate some of the features deemed to be included as part of a market standard refurbishment, where these systems are present in the base building:

- Boiler with 90% efficiency;
- Chiller with Coefficient of Performance of 3.3;
- 'T5' lighting;
- Air handling units (AHU) with specific fan power of 2.0W/l/s; and
- Power factor correction of 0.90.

Specifically selecting more energy efficient technologies will deliver further energy savings beyond that achieved by a standard refurbishment. For example, replacing a 20-year old boiler with a 'market standard' boiler will deliver a reduction in gas consumption because the new version will be typically 90% efficient compared to 65% or less for the old model. However, a 95% efficient boiler could be specified as part of the refurbishment, which would be more expensive but would save more energy. Similarly, the installation of LED lighting rather than T5 lighting would deliver significant energy savings albeit for a higher capital cost.

This study examines both the reduction in CO_2e emissions resulting from a market standard refurbishment and the additional reduction that can be achieved if enhanced energy efficiency improvements are specified.

4.2 Roles of Landlords and Occupiers

An owner occupier has control over all the factors influencing energy consumption, with the exception of location and proximity of other buildings. The situation is more complex where there is a landlord and occupier arrangement. The landlord has sole control over the quality of the building fabric and design, whereas the occupier is responsible for hours of use, density of occupation, the efficiency of IT and other equipment and setting internal temperatures.

Landlords and occupiers have varying influence on the energy efficiency of the installed building services. For example, a retail landlord has no control over the building services in a retail unit that has been let as a 'shell only' specification. In this example, the occupier installs all services except for the incoming gas main and power supply. In this case, the landlord has influence only over the thermal performance of the building fabric (i.e. in terms of insulating qualities and air tightness to reduce heat transfer). By contrast, in an office building fitted to Cat A, the landlord has installed the central plant together with lighting and terminal (e.g. fan coil) units throughout.

An occupier's small power and equipment alone can account for up to one third of total energy consumption. However, how the occupier runs the building services also has a significant influence on total energy consumption. Leaving lights and equipment on overnight, opening windows whilst the air conditioning or heating is running and setting a high temperature on the thermostatic controls are typical examples of inefficient behaviour in office buildings. Addressing these wasteful actions can have a negligible cost implication but the savings can be large and, therefore, the return on investment is very attractive. The occupier will have direct influence over these behaviours; however, the landlord can have an influence through the agreement of a Green Lease or Green Memorandum of Understanding with the occupier or by setting up a Green Building Management Group to engage occupiers in a building on energy and other sustainability matters.

4. IMPROVING ENERGY EFFICIENCY

The distribution of responsibilities and influence will vary within and across building uses. In this study, investment and associated savings have been split into those related to landlord and occupier 'controlled' areas whereas, in practice, responsibilities may vary[12].

4.3 Overview

The following section provides summary information and results for each of the analysed reference buildings.

For each building, the following information is provided in graphical form together with supporting commentary:

a. Capital investment required to achieve improved EPC ratings; information is presented as the absolute cost beginning with a standard refurbishment and then adding packages of more energy efficient technologies.
b. 'Cost effective' measures as defined by the seven-year payback test within MEES regulations for England and Wales. The full cost is included and compared against a 'do nothing' baseline.
c. Capital cost, net present energy savings and overall net present benefit over 15 years.
d. Internal rate of return (IRR) over 15 years.
e. Total carbon savings over 15 years, i.e. the total carbon savings achieved taking into account the changing carbon intensity of the grid.
f. The cost effectiveness of carbon savings over 15 years, i.e. the carbon saved divided by the net present cost of the measure over its lifetime.
g. Future carbon savings trajectory, covering each year between 2017 and 2030.
h. Reduction in direct carbon emissions (i.e. those from gas use only) compared to the 2017 baseline building.

The method for calculating each form of analysis is described in Appendix B.

For results a and b, the analysis is based on SBEM (Simplified Building Energy Model) modelling to calculate the EPC rating; for results c-g, the analysis is based on an estimate of the actual range in energy savings that might arise, drawing on energy use benchmarks for each building type and extrapolating the impact of energy efficiency measures using a combination of SBEM and CIBSE (Chartered Institute of Building Services Engineers) estimating methodologies.

For results c, d and e, the analysis of costs and carbon savings are split between those accruing to the 'landlord', i.e. based on investment in core services and landlord areas and savings in landlord areas only, and 'occupier', based on investment and savings in let areas only.

For results c-g, results are shown against a baseline of either 'do nothing' (full costs and savings) or 'market refurbishment' (marginal costs and savings) scenarios.

[12] It should be remembered that under MEES regulations, the responsibility for compliance sits entirely with the landlord and, should it prove cost effective, they may be obliged to invest in improving the energy efficiency of the occupier's space even if they received none of the resulting savings.

4. IMPROVING ENERGY EFFICIENCY

Improvements used in each building are explained in Table 4.1: have been used for each building:

Table 4.1: Key to improvement measures

Triple glazed	Triple glazed windows with a whole window U value of 0.8 Wm²K.
Double glazed	Double glazed windows with a whole window U value of 1.3 Wm²K.
New T5 lighting and controls (full)	Replacement of existing lighting and controls with new T5 luminaires (offices and retail space) delivering over 70 luminaire lumens per circuit Watt together with presence detectors and daylight compensation sensors. No daylight or presence detection sensors were included in retail and industrial buildings.
New LED lighting and controls (full)	Replacement of existing lighting and controls with new LED luminaires (offices and retail space) delivering over 100 luminaire lumens per circuit Watt together with presence detectors and daylight compensation sensors. No daylight or presence detection sensors were included in retail and industrial buildings.
Replace T8 lamps with T5	Replacement of existing T8 compact fluorescent tubes with new T5 lamps (delivering over 70 luminaire lumens per circuit Watt).
Replace T8 lamps with LED	Replacement of existing T8 compact fluorescent tubes with new LED lamps (delivering over 100 luminaire lumens per circuit Watt).
New variable speed pumps	Replacement of existing single speed heating pumps with variable speed pumps.
New gas boiler	Replacement of existing boiler with new 90% efficient condensing gas boiler.
New high efficiency (HE) gas boiler	Replacement of existing boiler with new 95% efficient condensing gas boiler.
Air source heat pump	Replacement of existing gas boiler with air source heat pump (ASHP). For air-conditioned buildings the ASHP also provides cooling in place of the existing chiller.
Voltage optimisation and PFC	Installation of power factor correction so that 95% of available current is used.
Refurbished fan coil units	Reconditioning existing fan coil units to incorporate new EC (Electronic Commutated) brushless drives to fans.
New high efficiency AHU	Replacement of existing plant with a new heat recovery air handling unit (AHU) capable of achieving a fan power of 2 W/m³.
New air cooled chiller	Replacement of existing chiller with new air cooled chiller with free cooling.
HIgh efficiency air cooled chiller	Replacement of existing chiller with new high efficiency centrifugal compressor air cooled chiller.
Photovoltaic panels	Installation of photovoltaic panels of 50kW peak capacity.

Packages

For each building, a series of packages of measures have been developed to show the effect of implementing several measures at the same time. The packages of measures for each building are designed to reflect reasonable actions that could be taken for:

- C – Combined packages addressing all areas of the building;
- L – Landlord plant and services to landlord areas;
- O – Occupier services to let areas.

4. IMPROVING ENERGY EFFICIENCY

Table 4.2 summarises the measures include in each package for each building.

Table 4.2: Build-up of packages of improvement measures for each building

Package	Standard refurbishment	EPC	Package	Energy efficient refurbishment	EPC
Office One					
C0	T5 lights + 91% eff. boiler + PFC	78	C1	LED lights + controls + 95% eff. boiler + pumps + PFC	63
			C2	LED lights + controls + 95% eff. boiler + pumps + PV + PFC	59
			C3	LED lights + controls + ASHP + pumps + PFC	40
			C4	LED lights + controls + ASHP + pumps + PFC + 50kWp PV	35
L0	T5 lights (20%) + 95% eff. boiler + PFC (95) + pumps	88	L1	LED lights (20%) + controls + ASHP + pumps + PFC	69
O0	T5 lights (80%) + controls	107	O1	LED lights (80%) + controls	106
Office Two					
C0	T5 lights + 91% eff. boiler + vs pumps + fan coils + PFC + AHU	64	C1	LED lights + controls + 95% eff. boiler + pumps + fan coils + PFC + chillers	51
			C2	LED lights + controls (100%) + ASHP + pumps + PFC + 50 kWp PV	50
L0	T5 lights (20%) + controls + AHU + Boilers + chiller + PFC	105	L1	LED lights + controls (20%) + 95% eff. boiler + vs pumps + PFC + chiller	102
			L2	LED lights + controls (20%) + ASHP + pumps + PFC	99
O0	T5 lights (80%) + controls + fan coils	82	O1	LED lights + controls (80%) + fan coils	78
Office Three					
C0	T5 lights (100%) + controls + 91% boilers + fan coils + vs pumps + chillers	73	C1	LED lights + controls (100%) + 95% boiler + fan coils + vs pumps + PFC + chillers (4.5)	59
			C2	LED lights + controls (100%)+ ASHP + fan coils + pumps + PFC	51
L0	T5 lights (20%) + controls + 91% boilers + vs pumps	119	L1	LED lights + controls (20%) + 95%boiler + vs pumps + PFC	116
			L2	LED lights + controls (20%) + 95% boiler + vs pumps + chiller (4.5) + PFC	106
			L3	LED lights + controls (20%) + controls + ASHP + PFC	100
O0	T5 lights (80%) + controls + fan coils	82	O1	LED lights + controls (80%) + fan coil	78

4. IMPROVING ENERGY EFFICIENCY

Table 4.2: Build-up of packages of improvement measures for each building (cont'd.)

Package	Standard refurbishment	EPC	Package	Energy efficient refurbishment	EPC
Office Four					
C0	T5 lights (100%) +95% boilers + vs pumps + fan coils	65	C1	LED lights + controls (100%) + ASHP + fan coils + vs pumps	49
	T5 lights (20%) + controls + 95% eff. boilers + Pumps	99	L1	LED lights + controls (20%) + ASHP	88
			L2	LED lights + controls (20%) + chiller	95
			L3	LED lights + controls (20%) + boiler + chiller + AHU	94
O0	T5 lights (80%) + controls+ fan coils	72	O1	LED lights + controls (80%) + fan coils	67
Retail warehouse					
			C1	T5 lights + controls + 95%boilers + pumps	
			C2	T5 lights + controls + fan coil	65
			C3	LED + controls + ASHP + pumps	50
			C4	LED + controls + chillers	58
			C5	Air tightness + roof insulation + LED + controls + FCU	51
			C6	LED lights + controls + boilers + PFC + pumps + chillers + AHU	51
			C7	Air tightness + roof insulation + LED lights + controls + FCU + boilers + PFC + pumps + chillers + AHU	37
Industrial warehouse					
			C1	Air tightness + roof and wall insulation + LED lights + controls	37
			C2	LED lights + controls + FCU + pumps + chillers + PFC + PV + radiant heaters	123
			C3	Packages C1+ C2 combined	27
			C4	LED lights (industrial space) + controls + radiant heater + PFC	144
			C5	LED lights (office space) + controls + FCU + pumps + chillers + boiler + PFC	160

5. OFFICES

There are many opportunities for the landlord to influence the energy consumption of their buildings. This is because office buildings are let with more building services systems in place in comparison to most other commercial buildings. Consequently, the landlord can significantly influence the energy efficiency of the heating, cooling and lighting systems installed in an office building either by directly installing the equipment themselves or by making it a condition in the agreement for lease, subject to the scale of the capital contribution provided.

5.1 Office One: Pre 1940s, Naturally Ventilated Narrow Plan

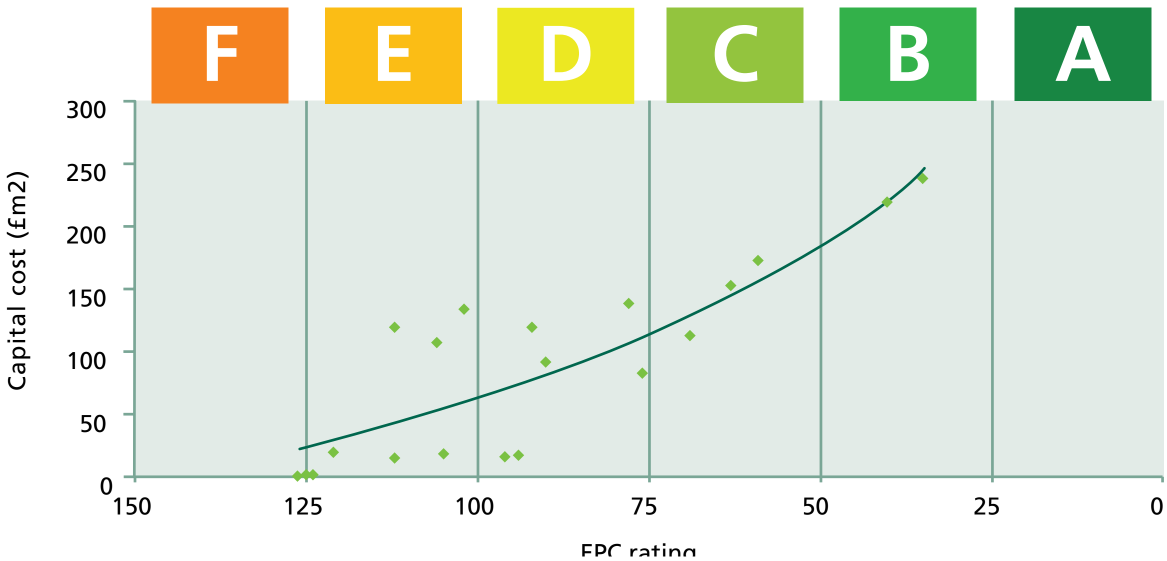
Reflects London Mid Town and West End offices which are predominantly period, dating from pre-1940.

- 5,400m^2
- Natural ventilation
- Narrow plan (60m x 15m)
- Storey height (3.7m)

- Glazing 50%, single
- Old gas boiler <60% efficient
- T8 light fittings
- Starting EPC = 126 (F)

Improving the EPC rating

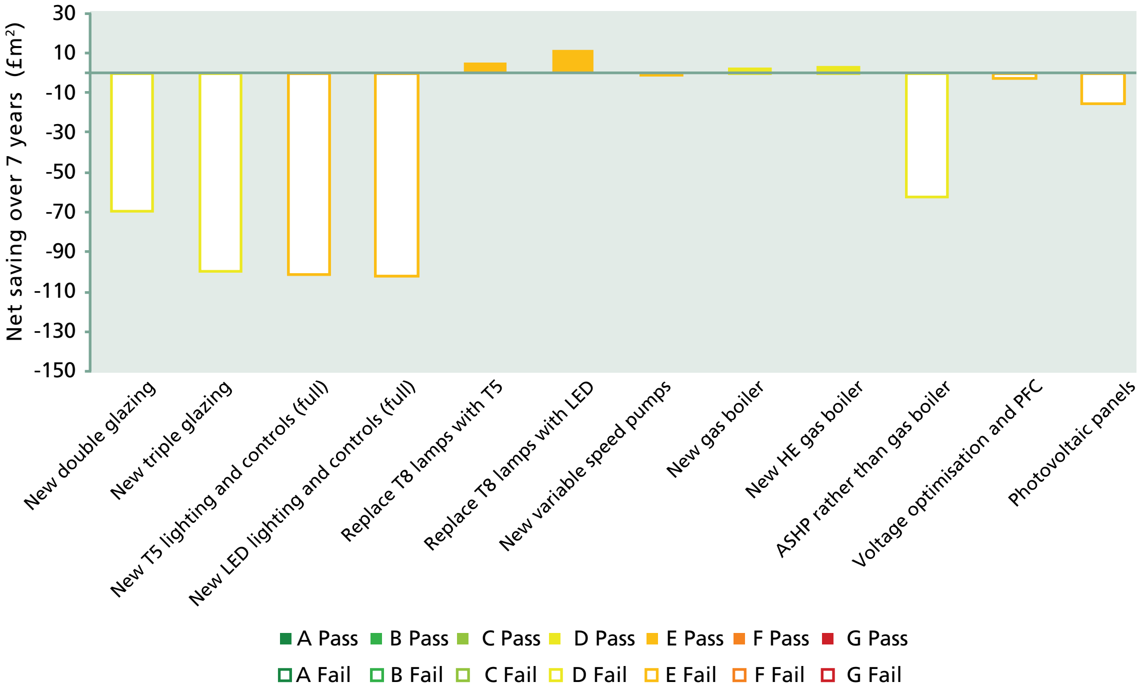
Figure 5.1: Office One - Capital costs of improving EPC rating



- The baseline building has an EPC of F and the landlord is therefore required to try to make cost effective improvements to comply with MEES regulations.
- The EPC can be improved to an E rating for a few £ per m^2 through installation of variable speed pumps.
- A rating of D could be achieved for less than £20 per m^2 through the installation of a new gas boiler.
- The building could achieve an EPC of B through investment in new LED lights and installation of an ASHP for heating. The cost would be in the region of £220 to £250 per m^2.
- An EPC of C could be achieved through installation of new LED lights and a new condensing gas boiler (95% efficient). The cost would be in the region of £150 to £180 per m^2.

5. OFFICES

Figure 5.2: Office One - Cost effectiveness of measures for MEES compliance



Note: Each measure improves the EPC rating above an F rating; however the level of improvements varies within the measures. None of the measures studied for Office 1 improves the building to an EPC rating of A, B or C, when implemented individually. Higher improvement in EPC rating is achievable by implementing packages introduced in the report.

- Each measure improves the EPC rating of the building above an F. However, most do not meet the seven year test prescribed by MEES regulations.
- Replacing existing T8 lights with T5 or (better) LED tubes does result in an undiscounted saving over seven years in comparison to the cost of installation and interest at the BoE base rate.
- Replacing the existing inefficient boiler with a new boiler (either 91% or 95% efficient) just meets the seven year test. The viability of this option may hinge on building specific circumstances.
- Full replacement of lighting and controls, either to T5 or LED does not meet the seven year test; however, these options would enhance the quality of the space.
- Similarly, installation of double or triple glazing does not meet the seven year test but would substantially enhance occupant comfort levels.

5. OFFICES

Costs and savings over 15 years

Figure 5.3: Office One - Costs and savings compared to 'doing nothing'

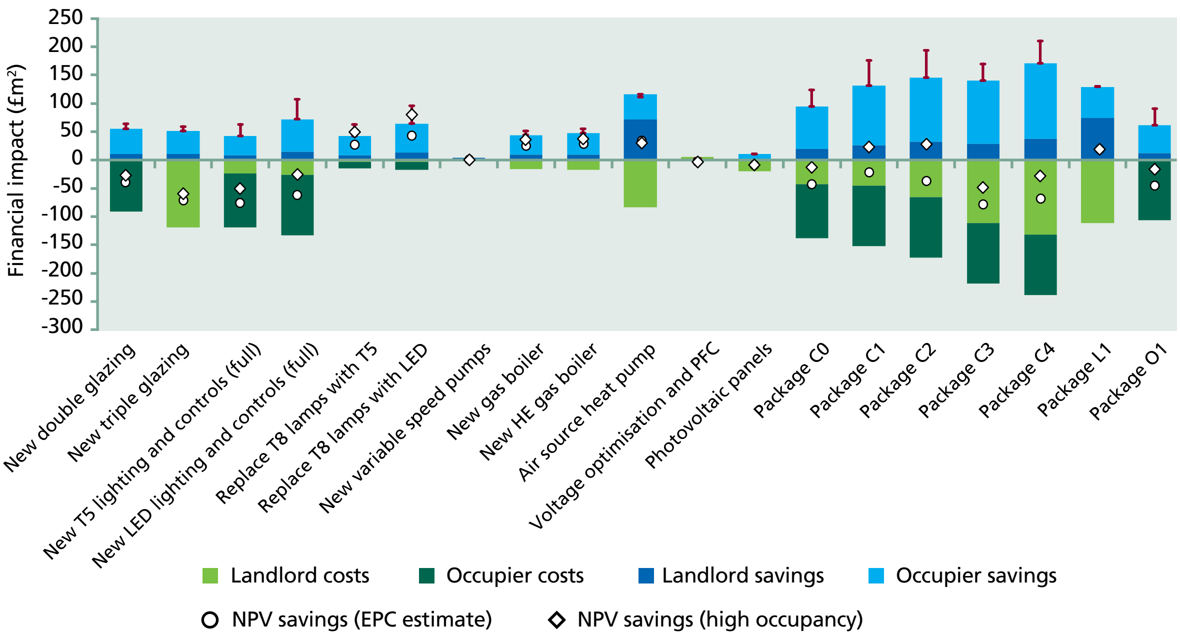
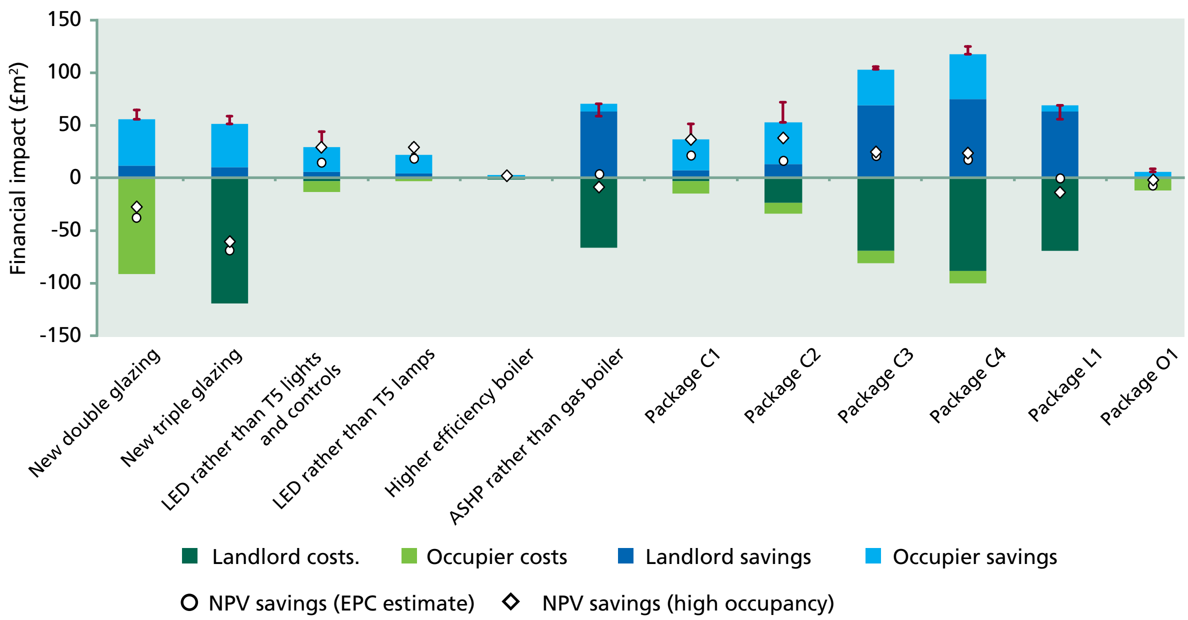


Figure 5.4: Office One - Costs and savings compared to 'market standard' alternative measures



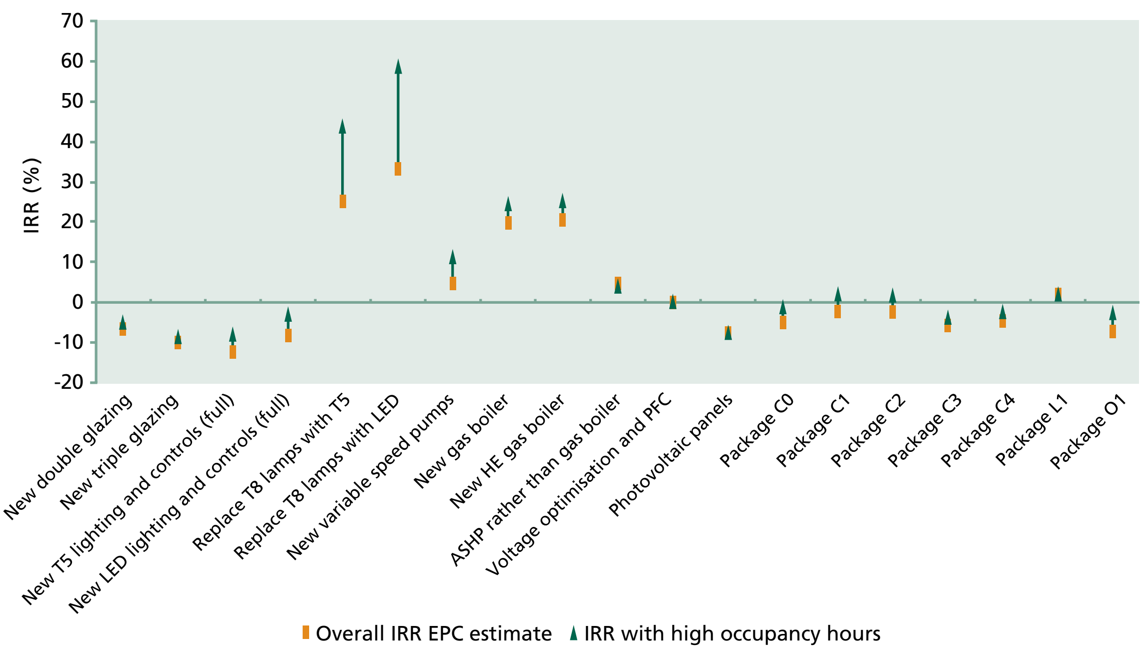
5. OFFICES

Key points

- Lamp replacement and boiler upgrades deliver a positive net benefit over 15 years, while glazing and new light systems do not breakeven with a discount rate of 3.5%.
- Based on EPC predictions, none of the packages of measures delivers a net saving over 15 years. However, if allowance is taken for the likely additional occupancy time of a busy office, then options C1 and C2 do deliver a saving.
- Because of payments from the RHI, ASHPs achieve a net saving over 15 years and this is slightly larger than that associated with gas boilers. This is significant because of the far greater carbon savings projected to be achieved through the use of electric heating in the coming decades.
- In comparison to a 'standard' alternative, there is a net benefit from investing in more energy efficient lighting and heating systems.
- The more energy efficient refurbishment option typically delivers a net benefit in comparison to a 'market standard' alternative. This includes the use of heat pumps instead of a gas boiler.

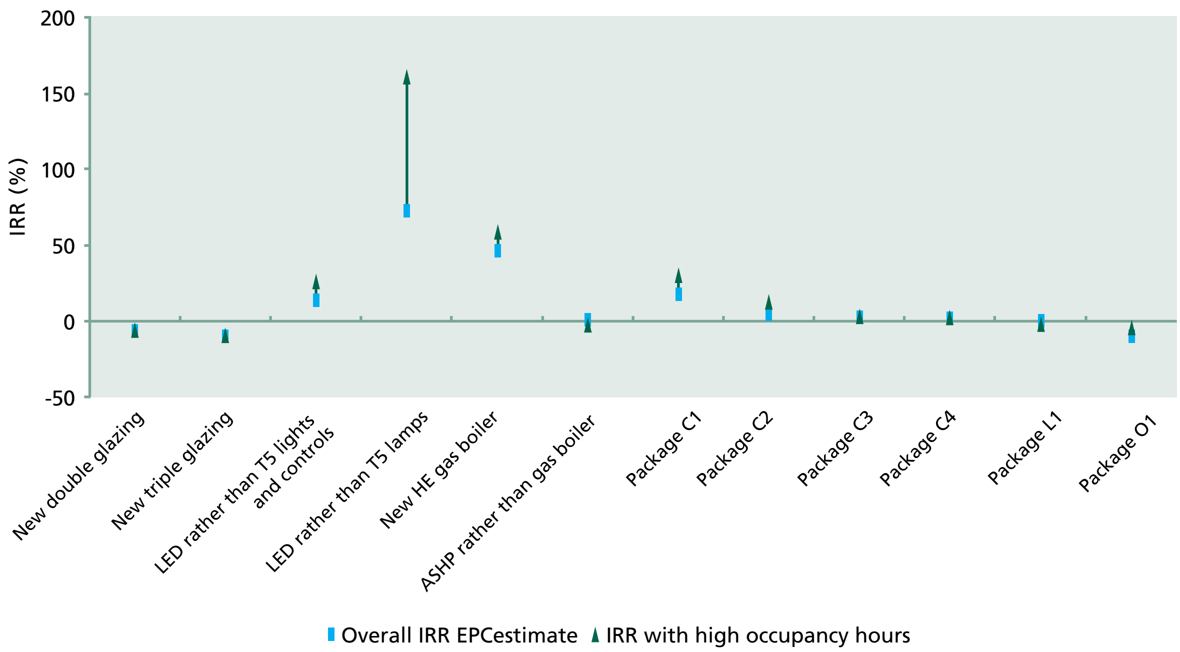
IRR of measures

Figure 5.5: Office One - Internal Rate of Return compared to 'doing nothing'



5. OFFICES

Figure 5.6: Office One - Internal Rate of Return compared to 'market standard' alternative measures



Key points

- Replacement of lamps within existing luminaire delivers a very strong IRR of over 30%, replacement of the whole lighting and control system does not achieve a positive IRR but should deliver substantial quality enhancements to the space.
- The specification of more energy efficient products typically achieves a positive IRR in comparison to less efficient alternatives; this is particularly the case for selecting LED lighting over T5 tubes, either as part of lamp or whole system replacements.

5. OFFICES

Cost of carbon reduction

Figure 5.7: Office One - Cost of carbon reduction compared to 'doing nothing'

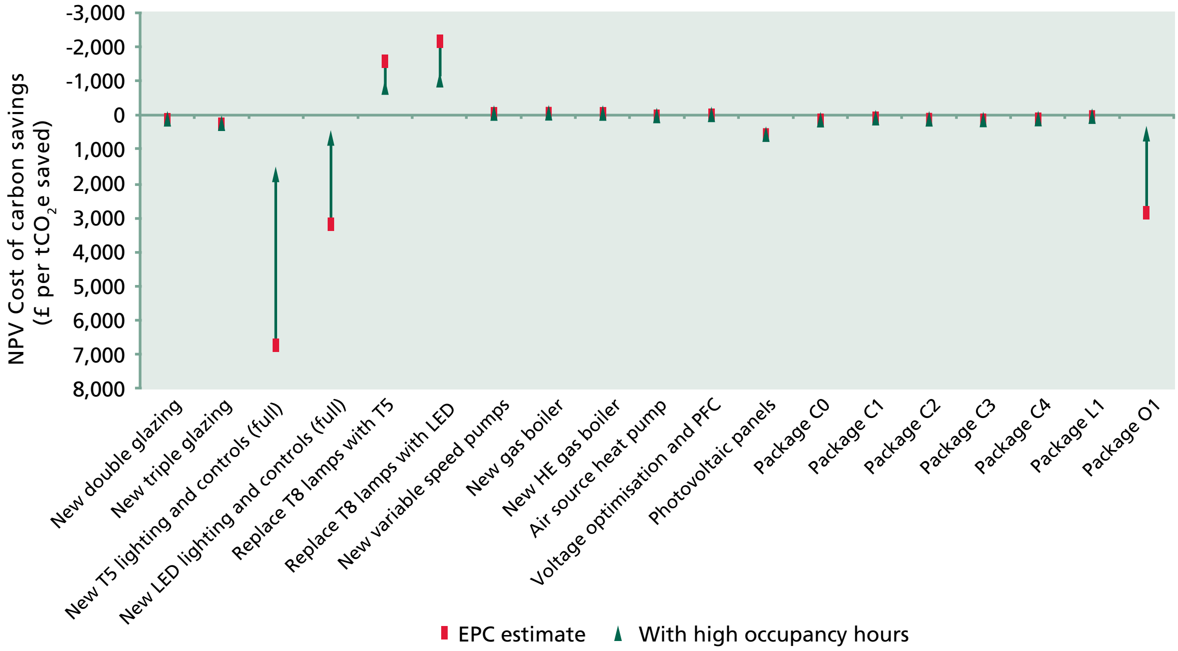
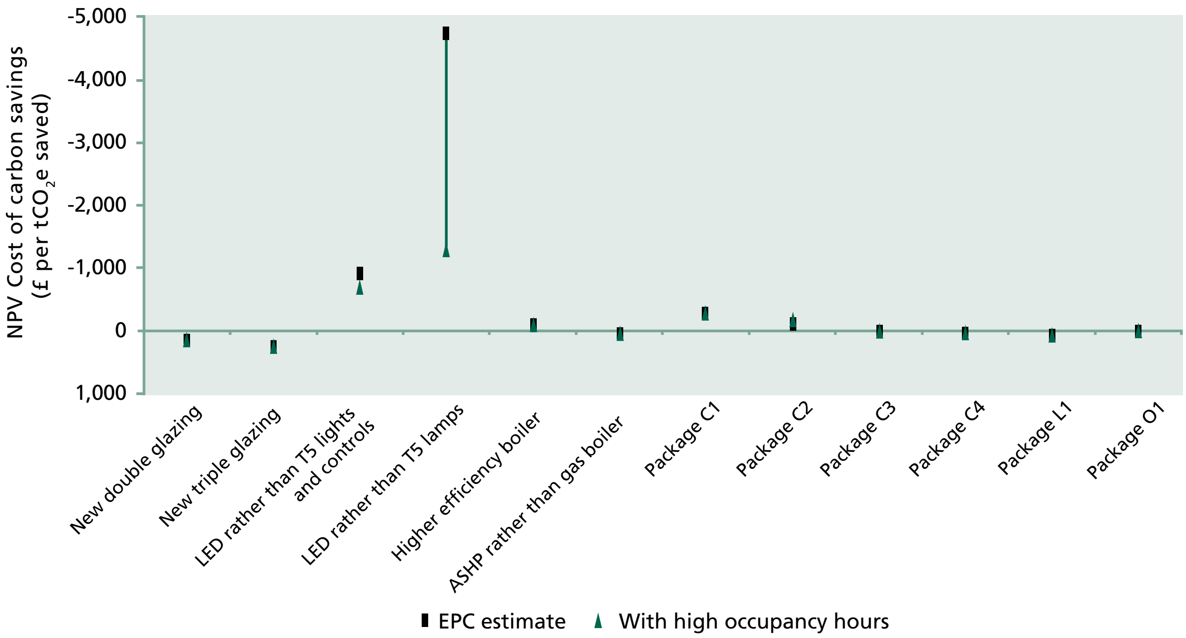


Figure 5.8: Office One - Cost of carbon reduction compared to 'market standard' alternative measures



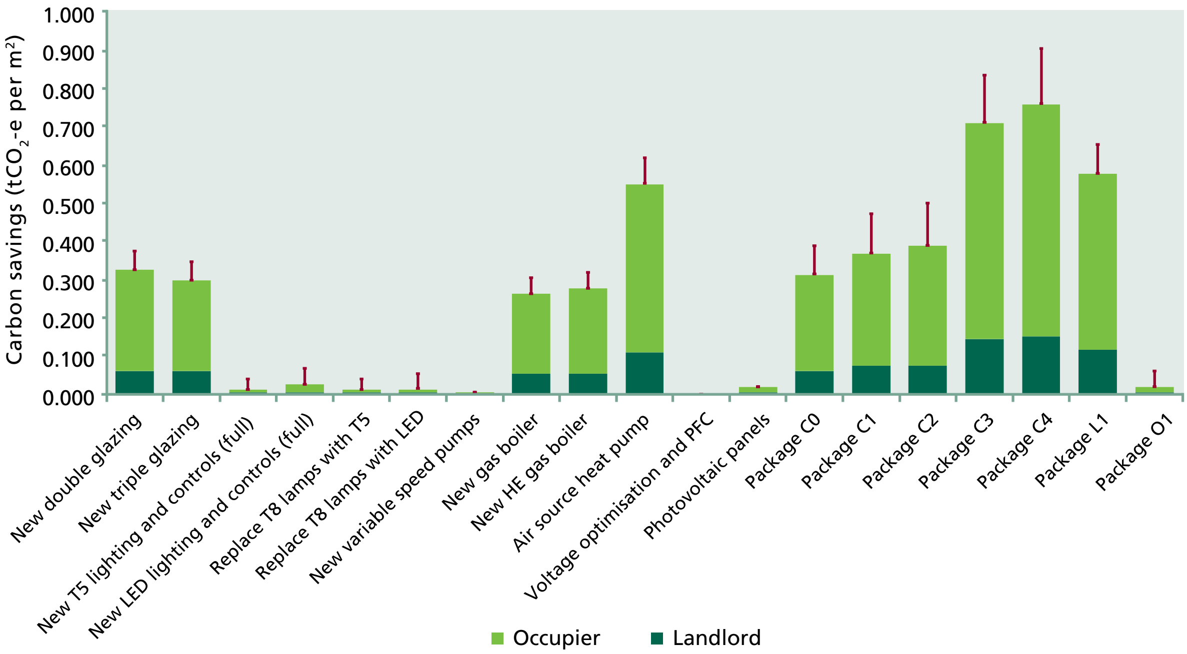
5. OFFICES

Key points

- In comparison to doing nothing, most measures show a saving or very small cost of carbon saving. Costs and savings of new light fittings skew the results because of the relatively small lifetime carbon savings of these measures(see Figure 5.8).
- Notwithstanding the point above, specification of the most efficient lights (e.g. LEDs) when replacing lamps or lighting systems is a highly cost effective way of saving carbon, delivering a significant benefit in comparison to a 'standard' alternative of T5 lights.

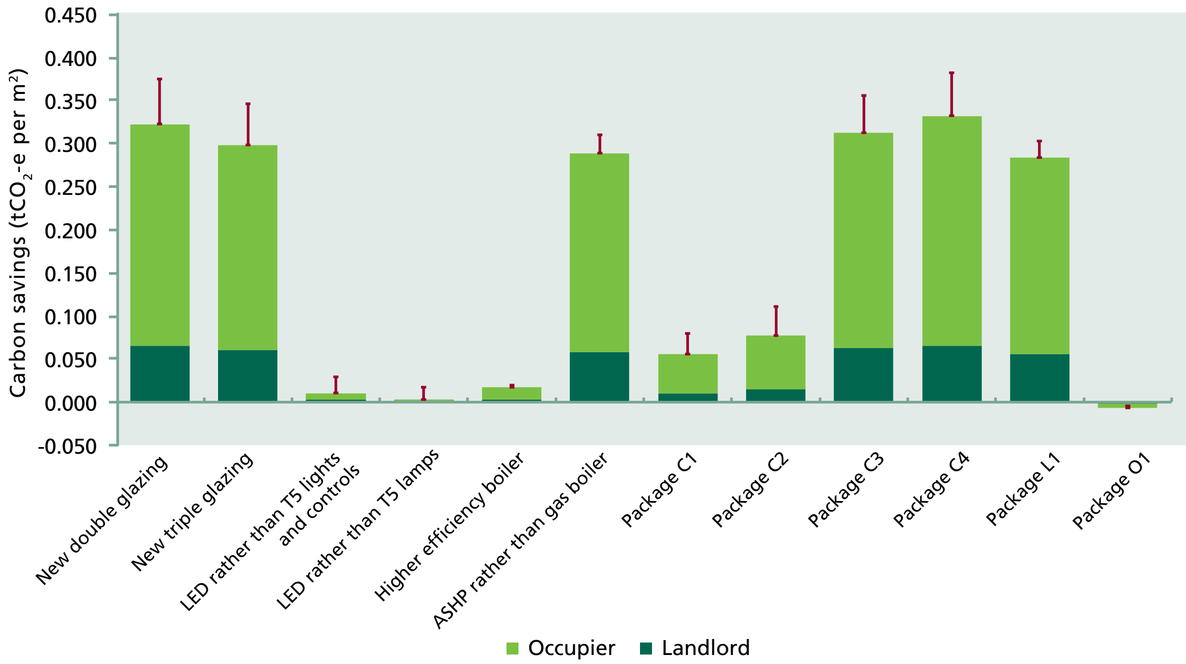
Total carbon saving

Figure 5.9: Office One - Total carbon saving compared to 'doing nothing'



5. OFFICES

Figure 5.10: Office One - Carbon savings compared 'market standard' alternative measures



Key points

- Lifetime carbon savings from lighting improvements are small relative to other options. This arises because the carbon value of the energy savings reduces over time as the carbon intensity of electricity reduces. In NV buildings this is often compounded by the need for additional gas fired heating to compensate for the reduced heat output from the new lights.
- Lifetime carbon savings are greatest for thermal efficiency measures (i.e. window improvements) and the switch to efficient and electric heating systems. The importance of reducing heat demand or providing this from efficient or low carbon sources is a result of the projected diminution of electricity consumption to the overall carbon footprint of a building. Of the options delivering significant lifetime carbon savings, heating efficiencies deliver the best direct financial return on investment although window replacements can deliver significant and readily apparent quality and comfort benefits.

5. OFFICES

Carbon reduction in comparison to 2017 emissions

Figure 5.11: Office One - Overall carbon emissions (gas and electricity)

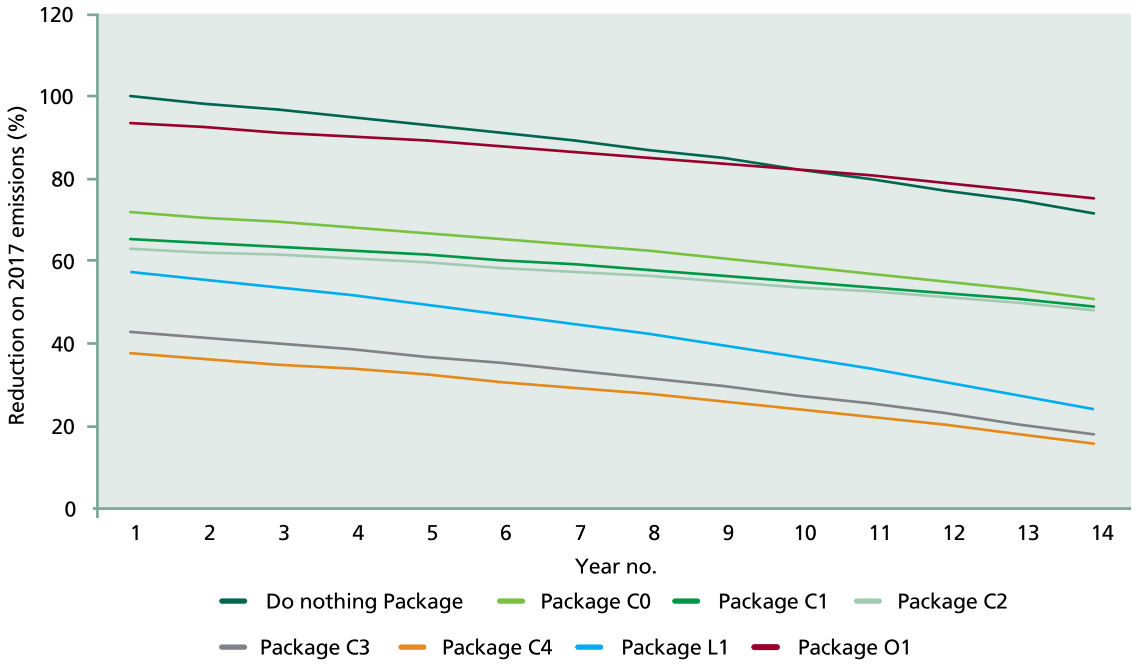
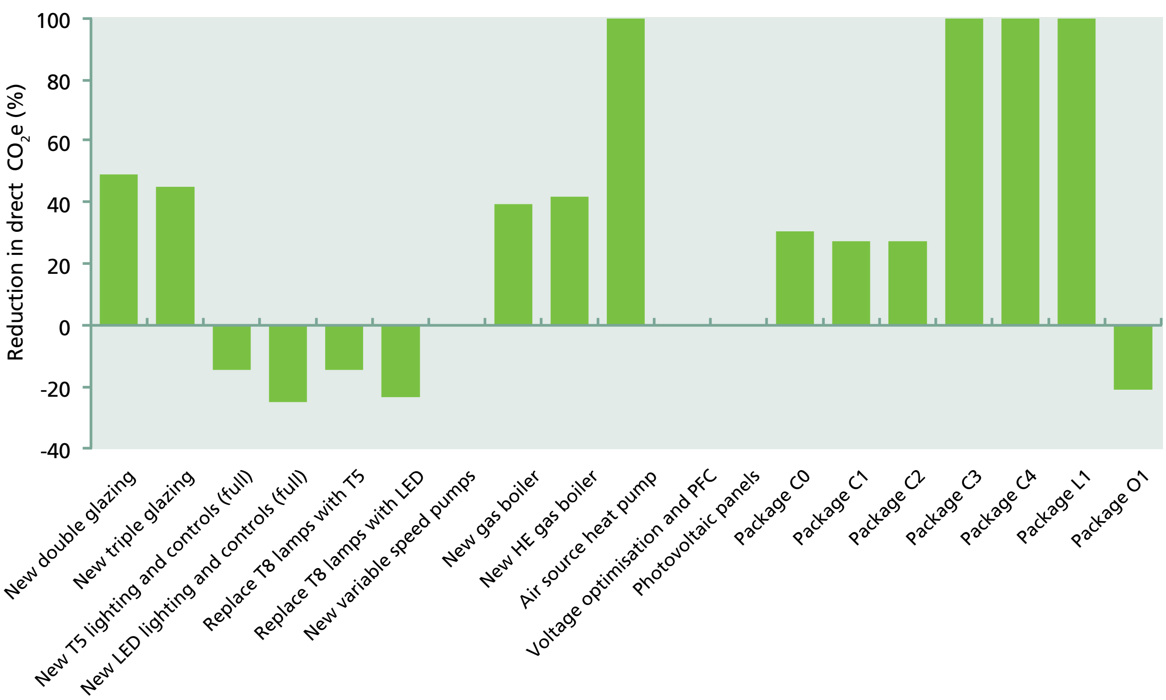


Figure 5.12: Office One - Reduction in direct emissions (gas only) compared to 2017



5. OFFICES

Key points

- Because of the projected decarbonisation of the electricity supply, all options (including a do nothing option) show reductions in total carbon emissions in the future.
- Each of the improvement packages delivers substantial additional benefit in comparison of the do nothing situation.
- Over time, the packages that involve the use of heat pumps (P3 and P4) become more beneficial than those retaining the use of gas boilers.
- In purely carbon terms, the savings associated with C1 and C2 diminish in comparison with the market standard refurbishment (C0); this is because these options do not substantially reduce the gas demand of the building, which becomes more significant as electricity decarbonises.
- Measures involving the replacement of gas heating with ASHP deliver complete reduction in direct carbon emissions from the office; more efficient gas heating systems and new windows also deliver direct emission reductions of over 40% against the baseline building.
- Lighting efficiency measures actually result in an increase in direct carbon emissions because the more efficient fittings are cooler and increase the need for heating of the building.

5. OFFICES

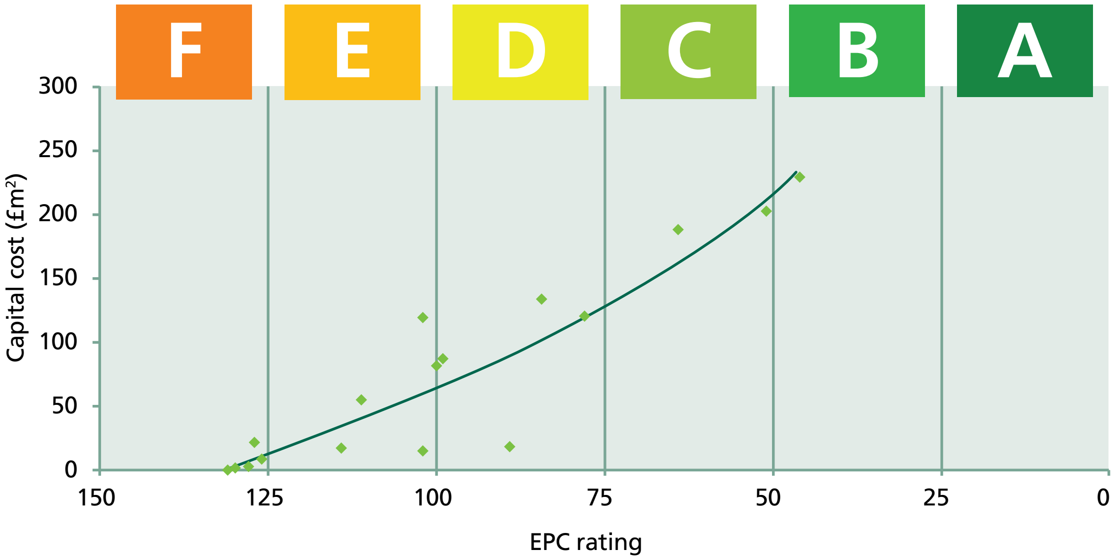
5.2 Office Two: Early 1990s, Partly Glazed Deep Plan Air-conditioned

Partly glazed air-conditioned early 1990s narrow plan office. Compliant with 1990 Part L Building Regulations.

- 5,400m²
- Air-conditioned
- Deep plan(30m x 30m)
- Storey height (3.7m)
- Glazing 50%, double
- Gas boiler c.65% efficient
- T8 light fittings
- Starting EPC = 131 (F)

Improving the EPC rating

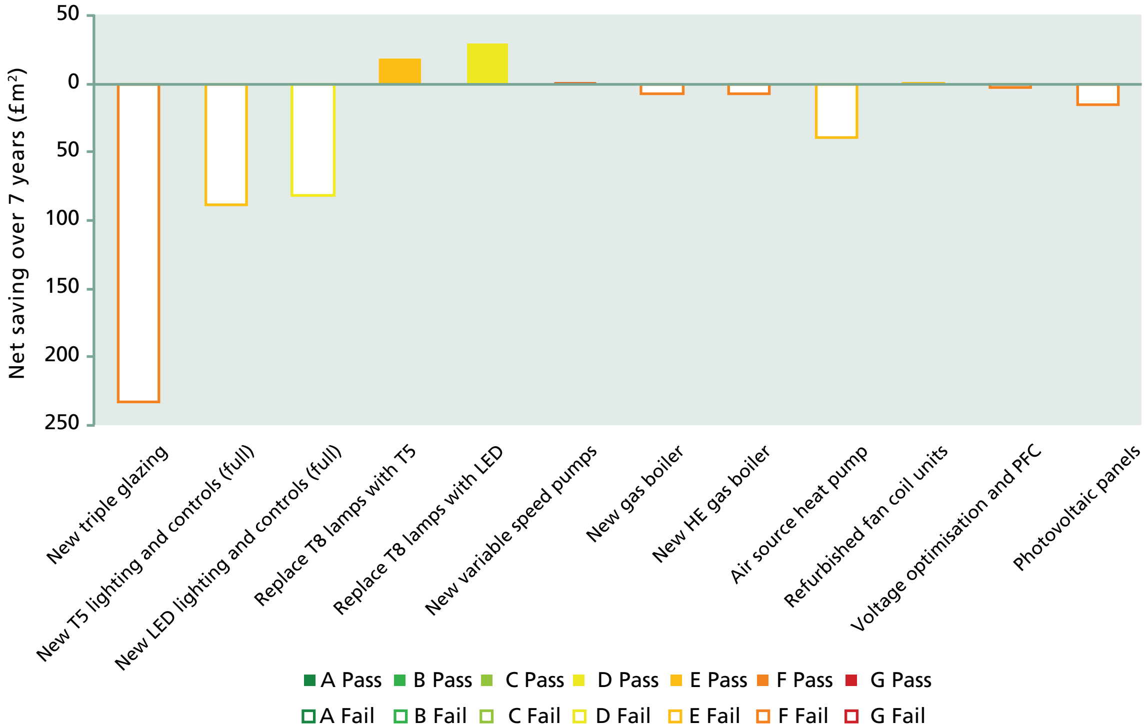
Figure 5.13: Office Two - Capital costs of improving EPC rating



- The baseline building has an EPC of F and the landlord is required, therefore, to try to make cost effective improvements to comply with MEES regulations.
- Installation of triple glazed windows increases (worsens) the EPC rating.
- Installation of new boiler plant is <£10 per m² but does not move the EPC above F.
- There is a correlation between investment costs and EPC rating. Outliers below the trend line relate to lighting and boiler upgrades.
- An E or D rating could be achieved through lighting upgrades with T5 (for E rating) or LED (for D rating) fittings. Relamping costs would be <£20 per m².
- The building could achieve an EPC of B through new LED lights, installation of an ASHP and 50kWp of photovoltaics. The cost would be £200 to £250 per m².

5. OFFICES

Figure 5.14: Office Two - Cost effectiveness of measures for MEES compliance



- Installation of triple glazing makes the EPC rating worse because it increases the energy required for cooling.
- All other measures improve the EPC rating of the building above an F. However, most do not meet the seven year test prescribed by MEES regulations.
- Replacing existing T8 lights with T5 or (better) LED tubes does result in an undiscounted saving over seven years in comparison to the cost of installation andinterest at the BoE base rate.
- Replacing the existing inefficient boiler with a new boiler (either 91% or 95% efficient) just fails the seven year test. The viability of this option may hinge on building specific circumstances.
- Full replacement of lighting and controls, either to T5 or LED does not meet the seven year test; however, these options would enhance the quality of the space.

5. OFFICES

Costs and savings over 15 years

Figure 5.15: Office Two - Costs and savings compared to 'doing nothing'

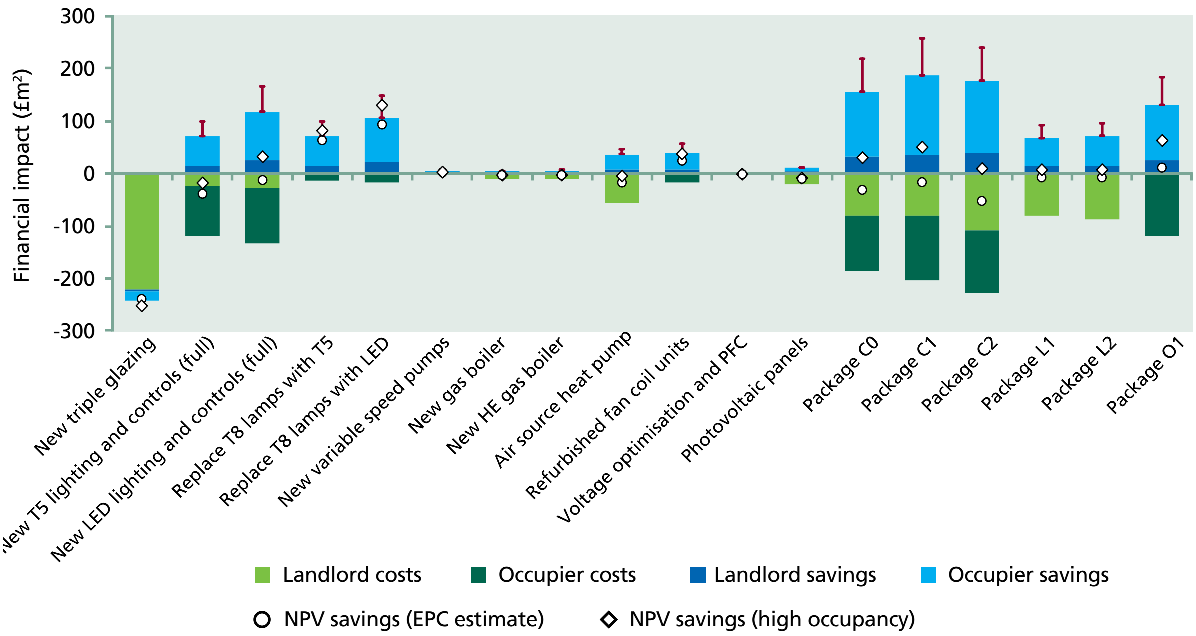
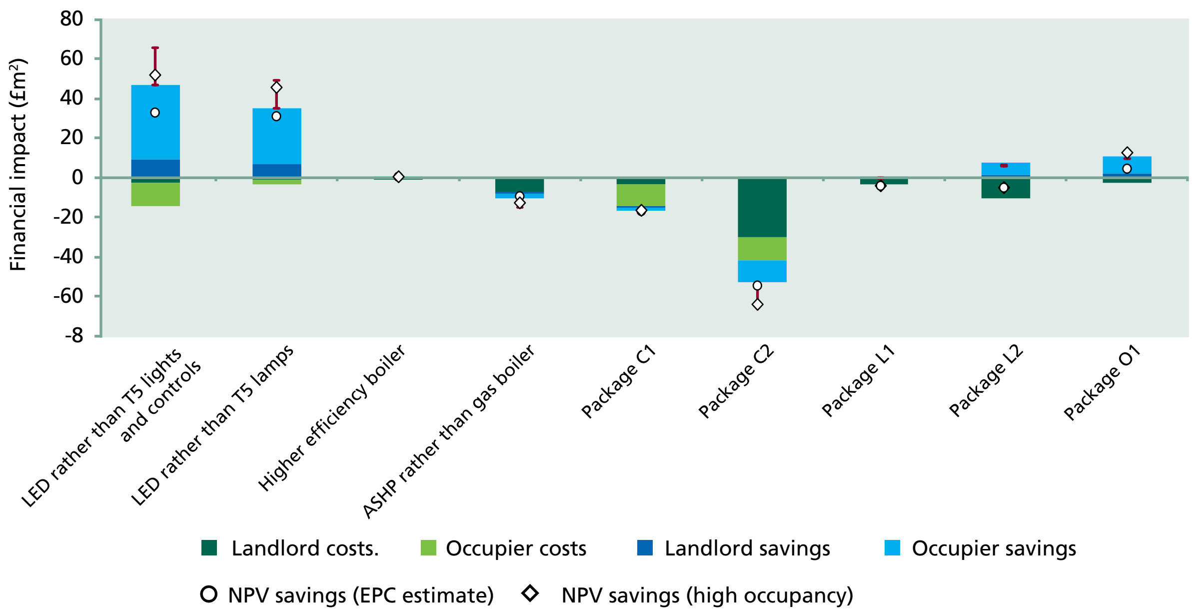


Figure 5.16: Office Two - Costs and savings compared to 'market standard' alternative measures



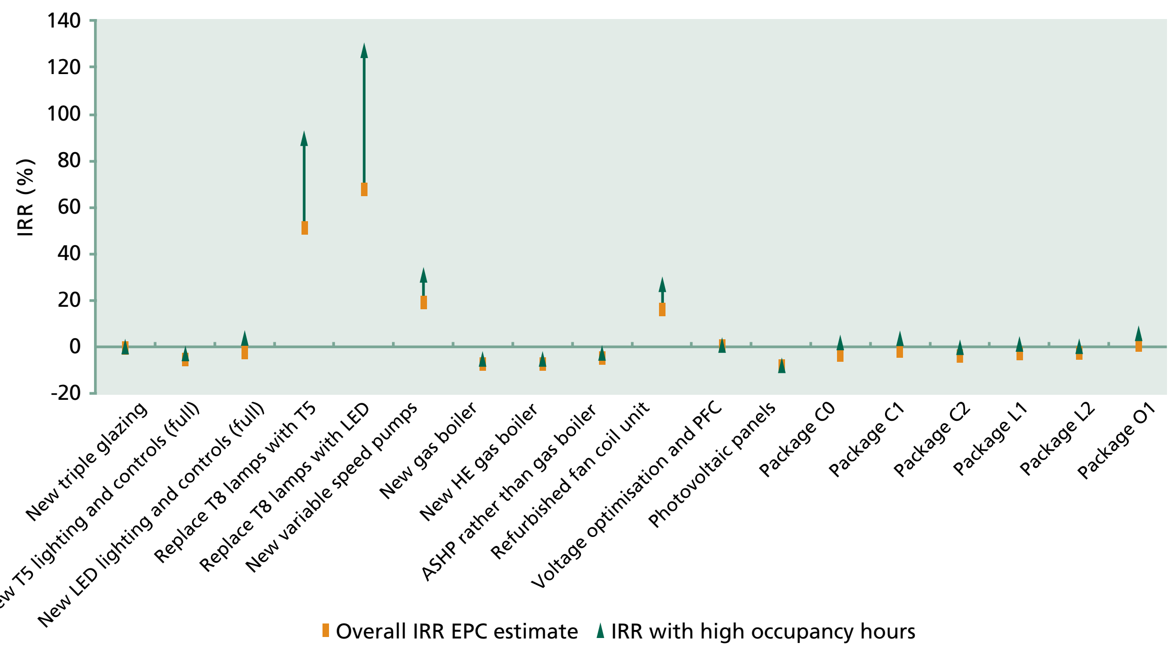
5. OFFICES

Key points

- The installation of triple glazed windows increases energy consumption and associated costs because it increases the amount of space cooling required. This means that this option is more expensive in terms of both capital and operating costs than leaving the original glazing in place.
- Lamp replacement and fan coil refurbishment deliver a positive net benefit over 15 years, while triple glazing, new light systems, and heat pumps do not breakeven with a discount rate of 3.5%.
- Based on EPC predictions, packages C0 (T5 lighting, fan coils, boiler and pumps and fans, power factor correction) and O1 (new lighting and fan coils) deliver net savings. With increased energy consumption from longer occupancy periods, option C1 (LED lighting, boilers, chillers, pumps, power factor correction) also shows a net saving.
- The use of ASHPs is less cost effective than for Office One because, as the measure is used for heating and cooling, it is not eligible for renewable heat incentive payments.
- In comparison to a 'standard' alternative, there is a net benefit from investing in more energy efficient lighting and gas boilers but a net cost from switching to an ASHP for heating and cooling.

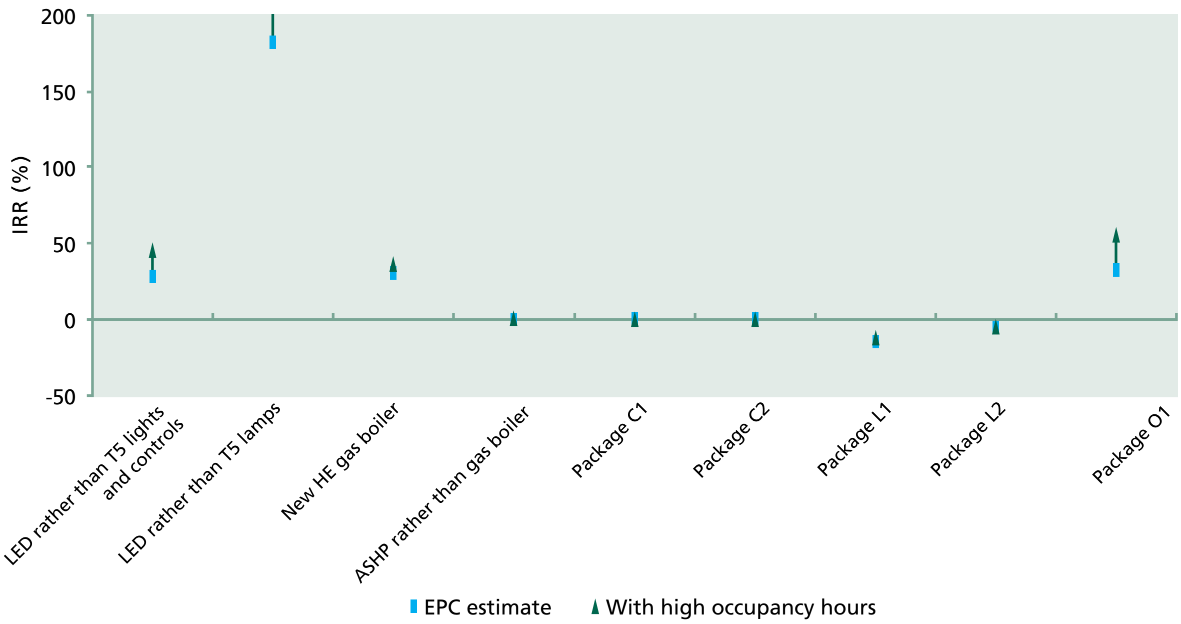
IRR of measures

Figure 5.17: Office Two - Internal Rate of Return compared to 'doing nothing'



5. OFFICES

Figure 5.18: Office Two - Internal Rate of Return compared to 'market standard' alternative measures



Key points

- Replacement of lamps within existing luminaire delivers a very strong IRR of over 50%; replacement of the whole lighting and control system does not achieve a positive IRR but should deliver substantial quality enhancements to the space.
- Refurbishment of fan coils to include EC drive units delivers a good return of over 15%. Similar returns are available from installation of variable speed pumps, albeit the total sum of the energy saving from this option is quite small.

5. OFFICES

Cost of carbon reduction

Figure 5.19: Office Two - Cost of carbon reduction compared to 'doing nothing'

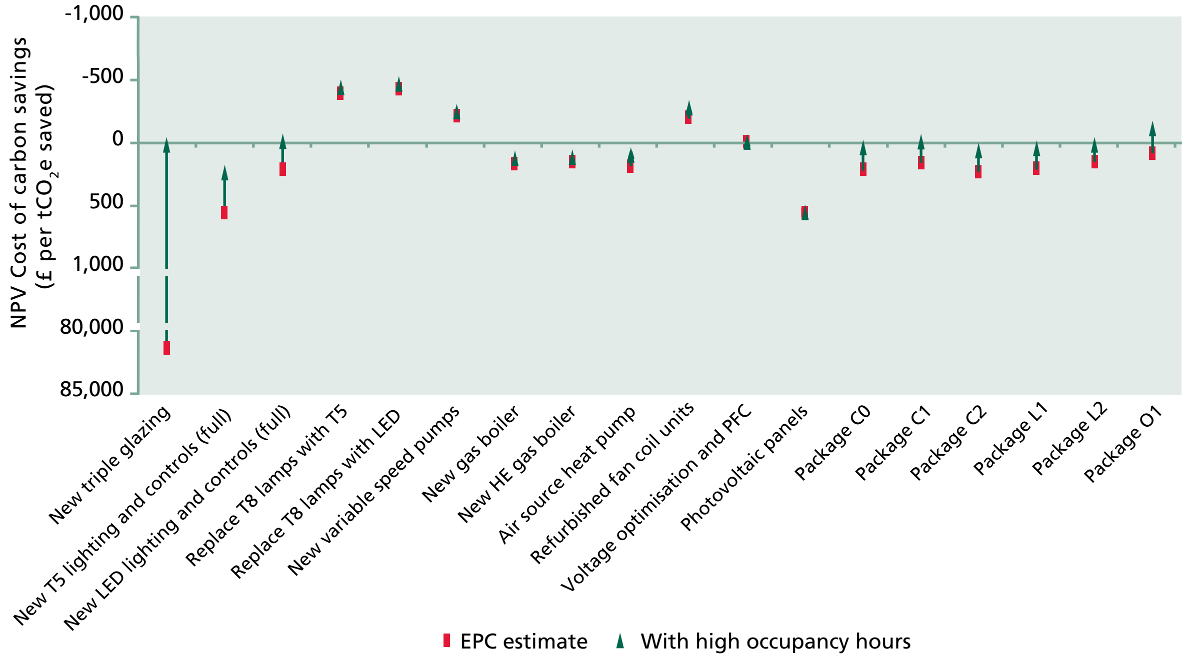
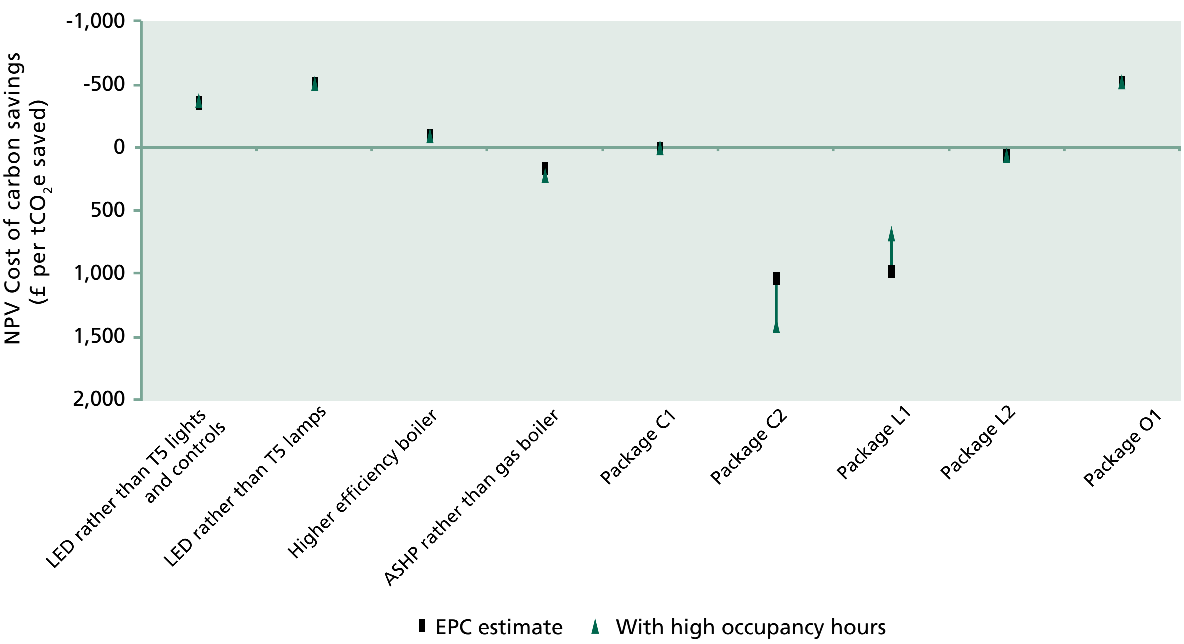


Figure 5.20: Office Two - Cost of carbon reduction compared savings compared 'market standard' alternative measures



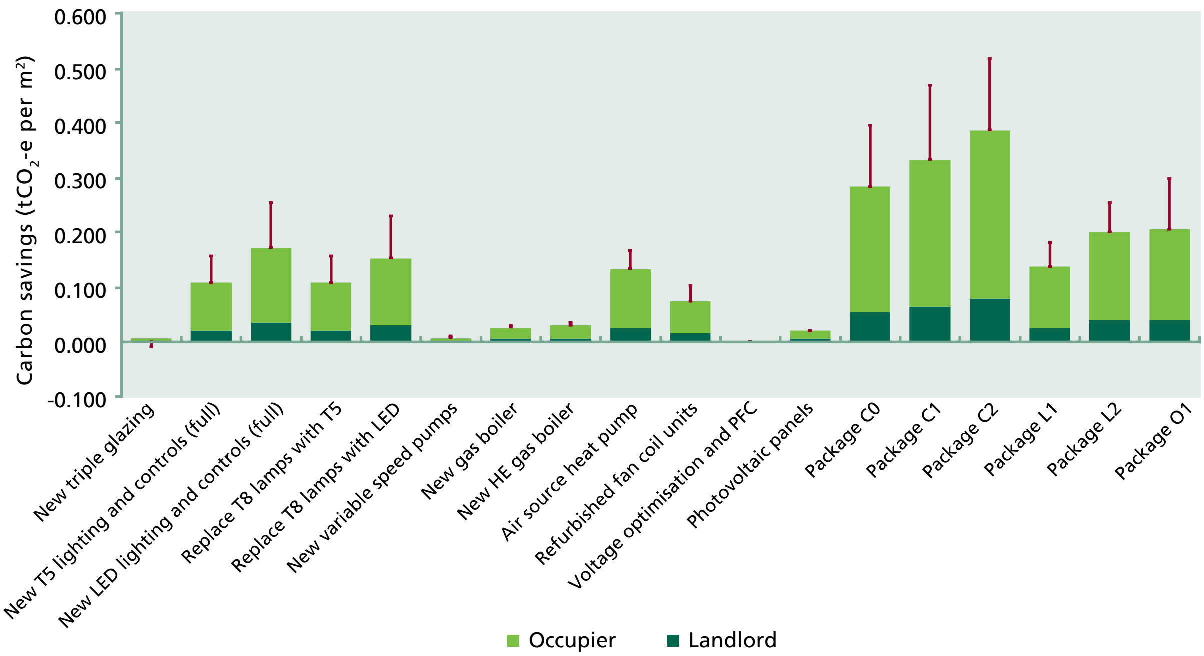
5. OFFICES

Key points

- In comparison to doing nothing, lamp and pump replacement and reconditioned fan coils show a net saving in addition to reducing carbon emissions. For other individual measures the cost of reducing carbon emissions is around £200 per tonne of carbon saved and more than this for glazing and PV installations.
- Specifying the most efficient lighting systems is a highly efficient way to save carbon if lights are being addressed as part of a refurbishment.

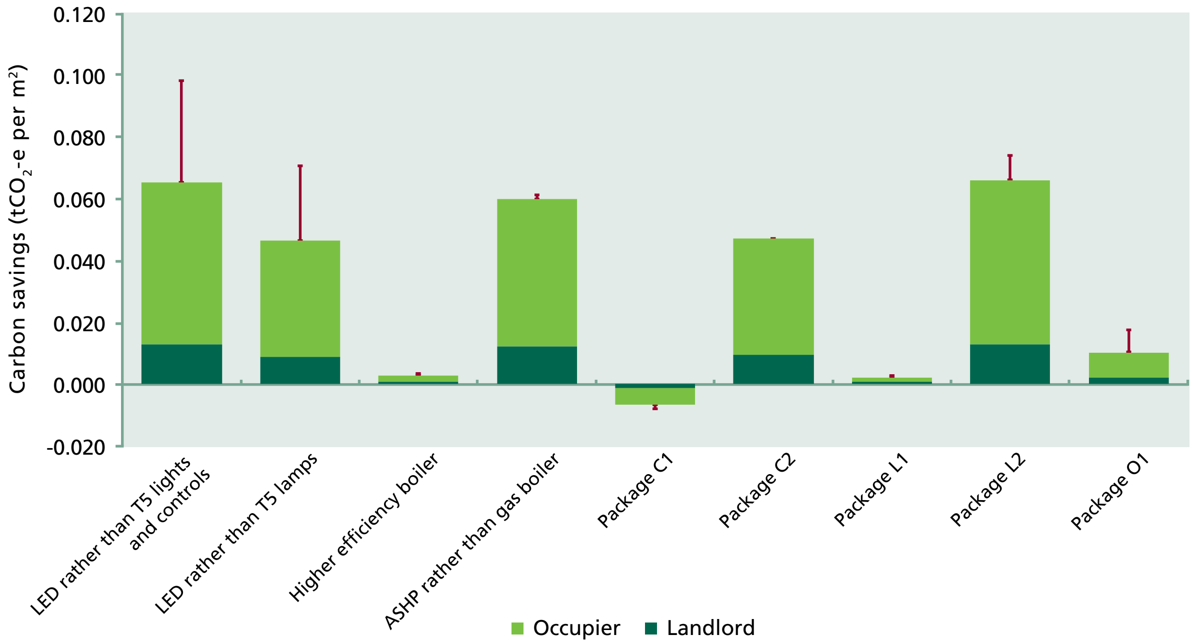
Total carbon saving

Figure 5.21: Office Two - Carbon saving compared 'doing nothing'



5. OFFICES

Figure 5.22: Office Two - Carbon saving compared to 'market standard' alternative measures



Key points

- Carbon savings from boiler improvements are small relative to other options. This is because of the reduced significance of heating in the buildings current carbon emissions. Savings from switching to a heat pump (ASHP) for heating are more substantial.
- Lighting efficiencies deliver the largest lifetime carbon savings and are also (in the case of lamp replacements) among the most cost effective.
- Packages containing lighting and ASHP technologies deliver the largest carbon savings.
- Substantial savings are available through improvements to occupier space only without addressing central plant.

5. OFFICES

Carbon reduction in comparison to 2017 emissions

Figure 5.23: Office Two - Reduction in carbon emissions (gas and electricity)

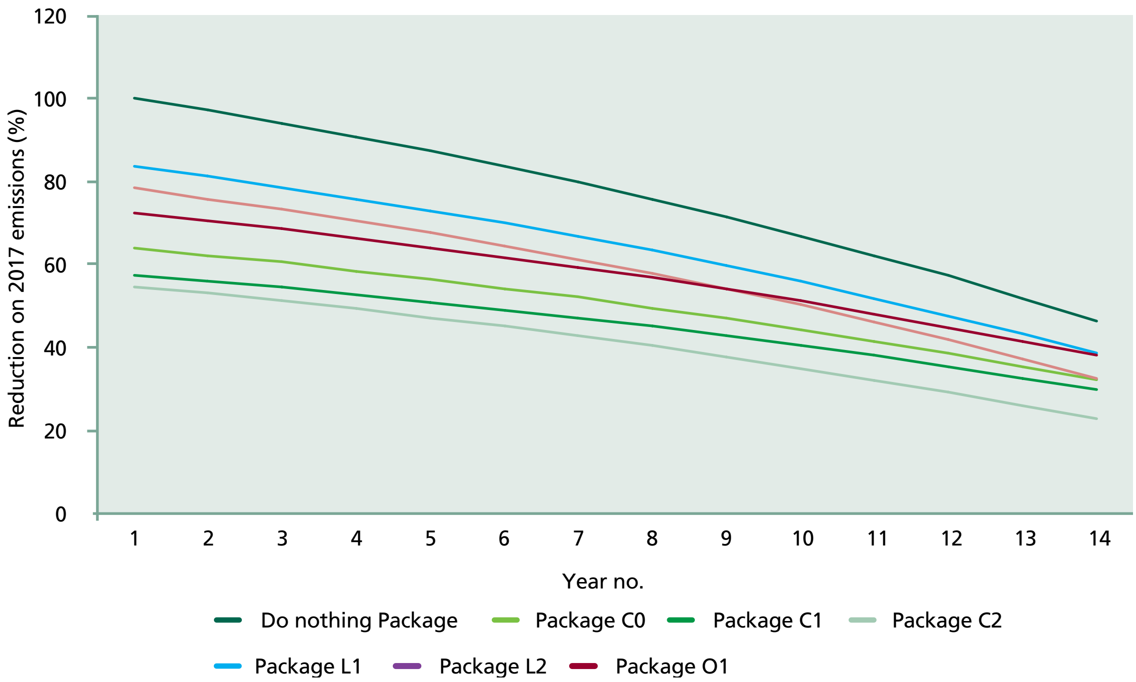
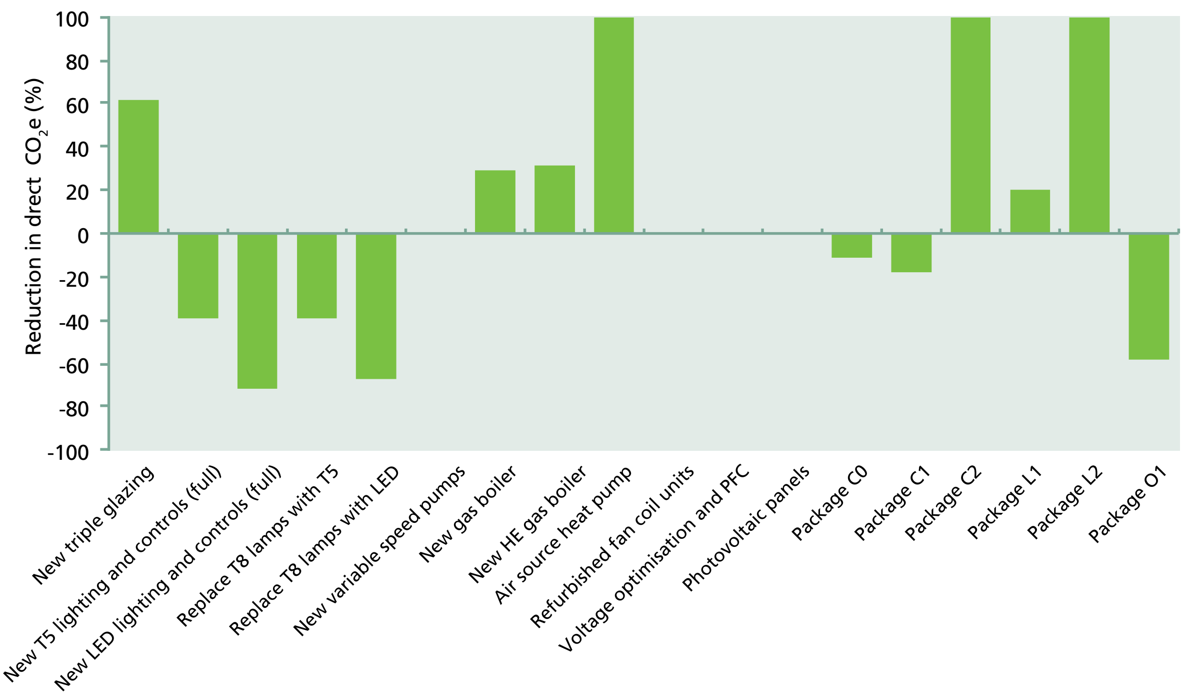


Figure 5.24: Office Two - Reduction in direct emissions (gas only) compared to 2017



5. OFFICES

Key points

- Because of the projected decarbonisation of the electricity supply, all options (including a do nothing option) show reductions in total carbon emissions in the future.
- Each of the improvement packages delivers substantial additional benefit in comparison of the do nothing situation. By 2030, building emissions from package C1 (incl. LED lights and ASHP for heating and cooling) are nearly 80% lower than for the 2017 baseline building and are under half the emissions of the 'do nothing' option.
- Over time, the packages that involve the use of heat pumps (C2 and L2) become more beneficial than those retaining the use of gas boilers.
- Measures involving the replacement of gas heating with ASHP deliver a complete reduction in direct carbon emissions from the office; more efficient gas heating systems and new windows also deliver direct emission reductions of over 40% against the baseline building.
- Lighting efficiency measures actually result in an increase in direct carbon emissions because the more efficient fittings are cooler and increase the need for heating of the building.

5. OFFICES

5.3 Office Three: Post 2002, Highly Glazed Deep Plan Air-conditioned

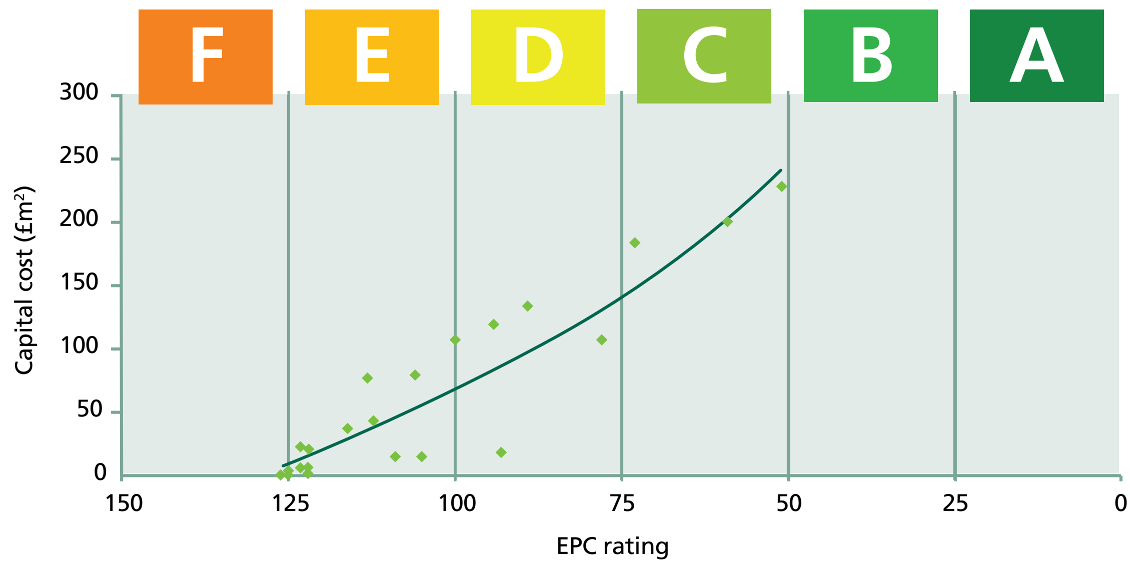
Highly glazed deep plan air-conditioned office. Compliant with 2002 Part L Building Regulations.

- 5,400m²
- Air-conditioned
- Deep plan (30m x 30m)
- Storey height (3.7m)

- Glazing 80%, double
- Gas boiler c.80% efficient
- T8 light fittings
- Starting EPC = 126 (F)

Improving the EPC rating

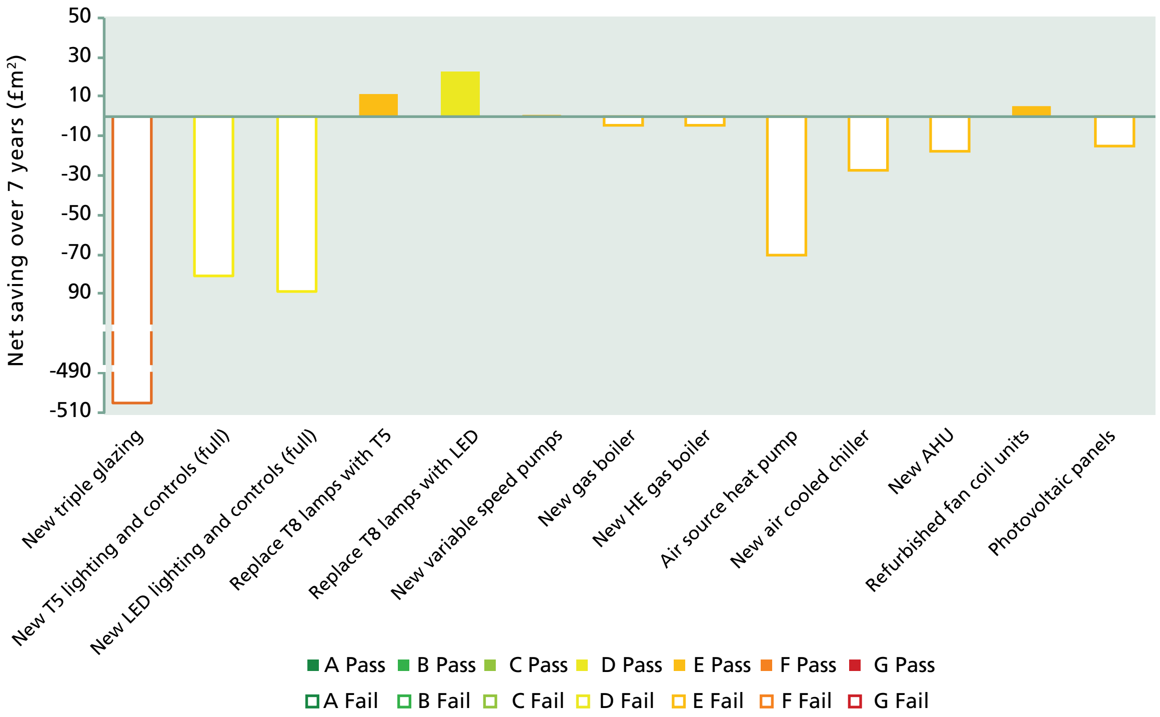
Figure 5.25: Office Three - Capital costs of improving EPC rating



- The baseline building has an EPC of F and the landlord is required, therefore, to try to make cost effective improvements to comply with MEES regulations.
- The EPC can be improved to an E rating for a under £10 per m² through installation new boiler plant.
- A rating of D could be achieved for less than £20 per m² through the installation new LED lighting in existing luminaires.
- The building could achieve an EPC of B through investment in new LED lights an ASHP (for heating and cooling) PFC, reconditioned fan coils and 50kWp photovoltaics. The cost would be in the region of c. £260 per m².
- An EPC of C could be achieved through installation of new T5 lights, a new gas boiler (91% efficient) and reconditioned fan coil units with EC drives. The cost would be in the region of £180 per m².

5. OFFICES

Figure 5.26: Office Three - Cost effectiveness of measures for MEES compliance



- Installation of triple glazing makes the EPC rating worse because it increases the energy required for cooling.
- All other measures improve the EPC rating of the building above an F. However, most do not meet the seven year test prescribed by MEES regulations.
- Replacing existing T8 lights with T5 or (better) LED tubes result in an undiscounted saving over seven years in comparison to the cost of installation and interest at the BoE base rate.
- Installation of variable speed pumps delivers a small net benefit over seven years and, in this example, is just sufficient to achieve an EPC of E.
- Refurbishment of existing fan coils with the installation of EC drive units delivers a net benefit and achieves an EPC of E.

5. OFFICES

Costs and savings over 15 years

Figure 5.27: Office Three - Costs and savings compared to 'doing nothing'

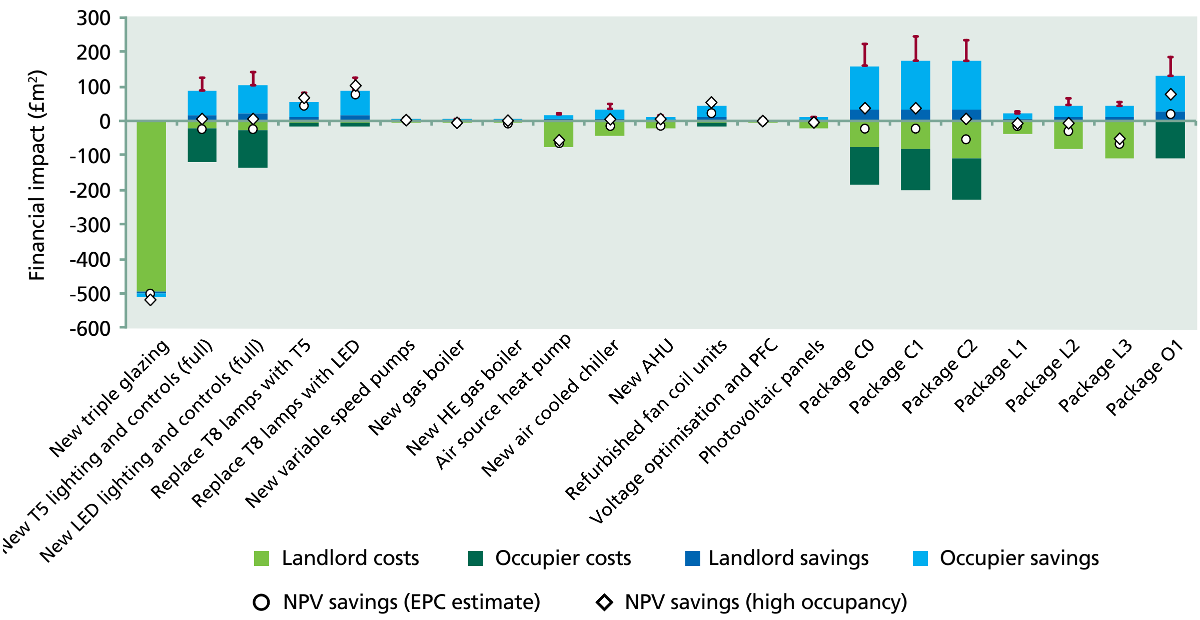
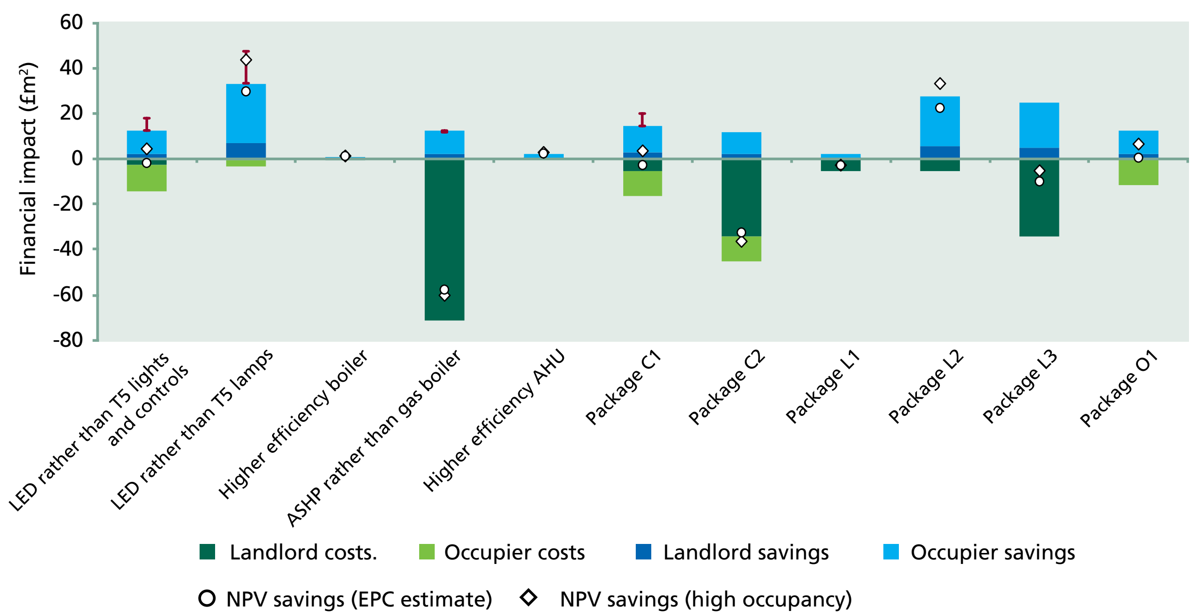


Figure 5.28: Office Three - Costs and savings compared to 'market standard' alternative measures



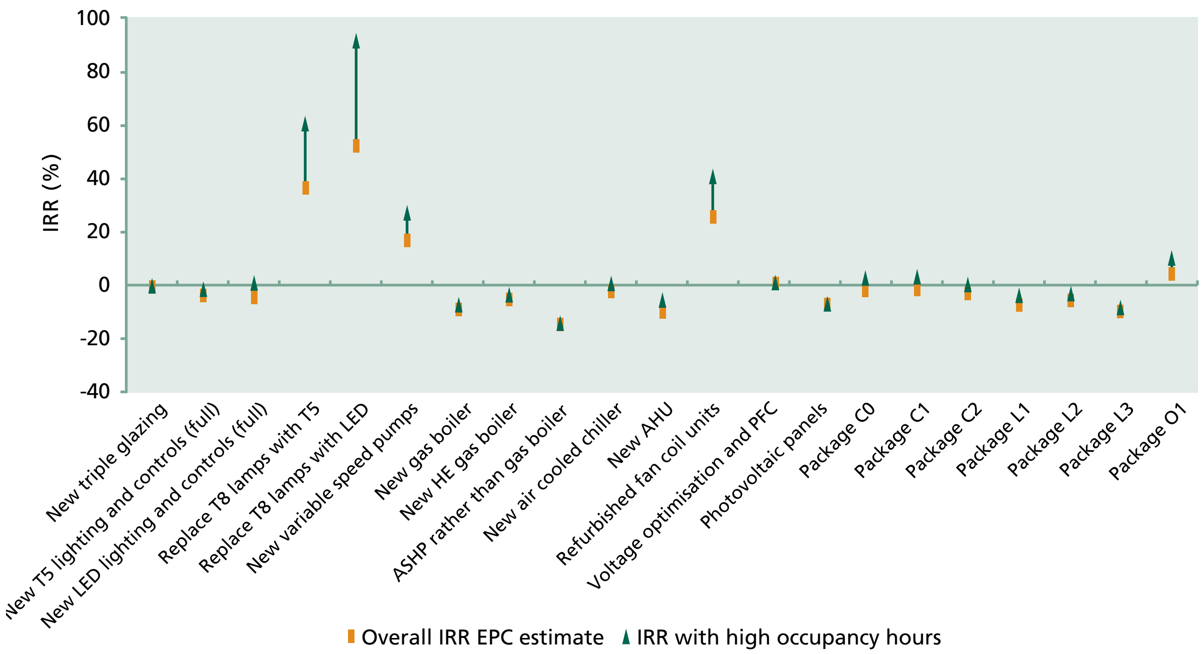
5. OFFICES

Key points

- The installation of triple glazed windows increases energy consumption and associated costs because it increases the amount of space cooling required. This means that this option is more expensive in terms of both capital and operating costs than leaving the original glazing in place.
- Lamp replacement and fan coil refurbishment deliver a positive net benefit over 15 years, while glazing, new light systems and heat pumps do not breakeven with a discount rate of 3.5%.
- Based on EPC predictions onlypackage O1 (new lighting and fan coils) delivers a net saving over 15 years. However, if allowance is taken for the likely additional occupancy time of a busy office, then packages CO and C1 (new lighting, boilers and refurbishment of fan coil units) also deliver net savings.
- The use of ASHPs is less cost effective than for office One because, as the measure is used for heating and cooling, it is not eligible for renewable heat incentive payments.
- In comparison to a 'standard' alternative, there is a net benefit from investing in more energy efficient lighting and heating systems.

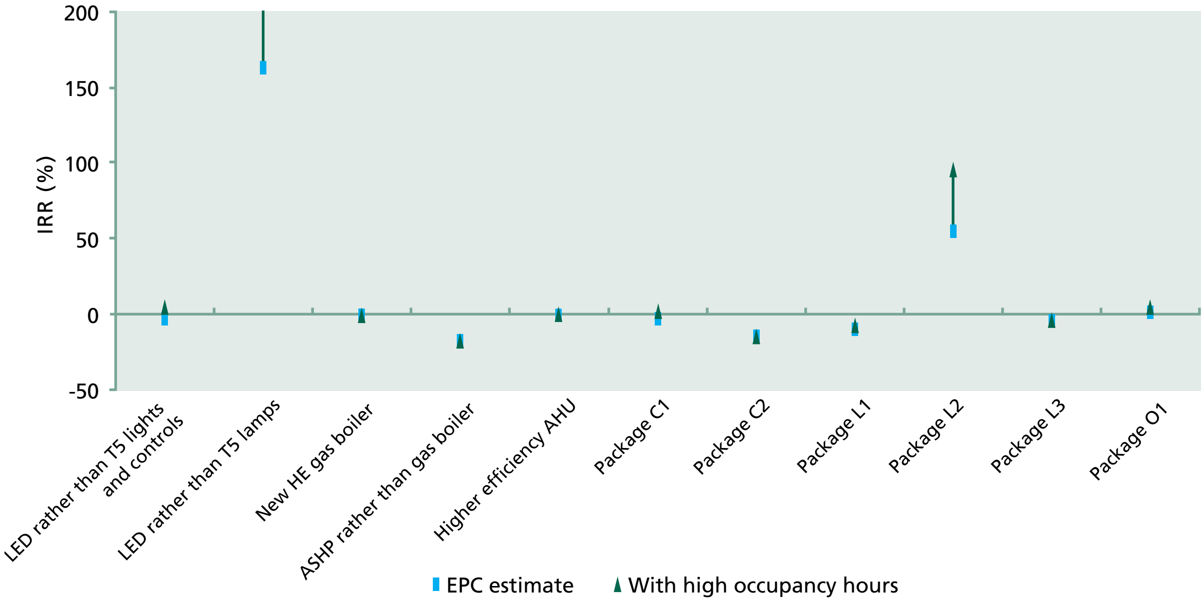
IRR of measures

Figure 5.29: Office Three - Internal Rate of Return compared to 'doing nothing'



5. OFFICES

Figure 5.30: Office Three - Internal Rate of Return compared to 'market standard' alternative measures



Key points

- Replacement of lamps within existing luminaire delivers a very strong IRR of over 30%; replacement of the whole lighting and control system does not achieve a positive IRR but should deliver substantial quality enhancements to the space.
- Refurbishment of fan coils, to include EC drive units, delivers a good return of over 15%. Similar returns are available from installation of variable speed pumps, albeit the total sum of the energy saving from this option is quite small.
- Packages C0 and C1 show slightly positive returns when for the 'actual' energy consumption scenario, i.e. where account is taken of additional periods of occupation.
- The returns for more energy efficient packages of measures are typically negative for whole building (i.e. combined) or landlord only activities, but are positive for occupier areas (as a result of efficiencies in lighting).

5. OFFICES

Cost of carbon reduction

Figure 5.31: Office Three - Cost of carbon reduction compared to 'doing nothing'

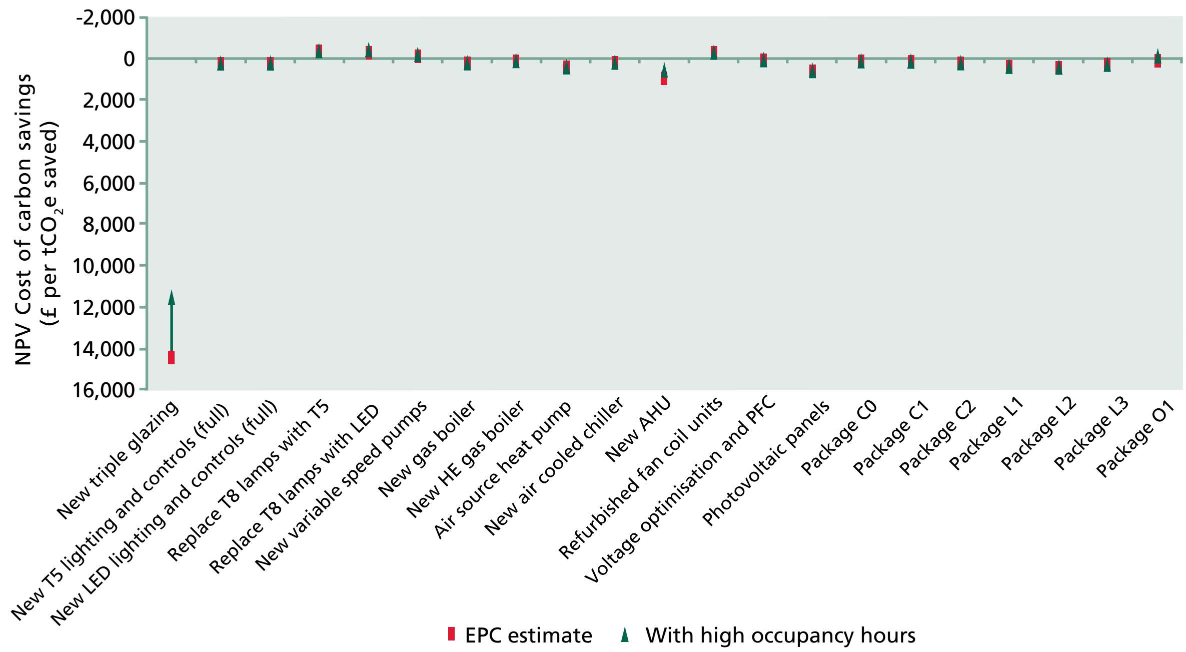
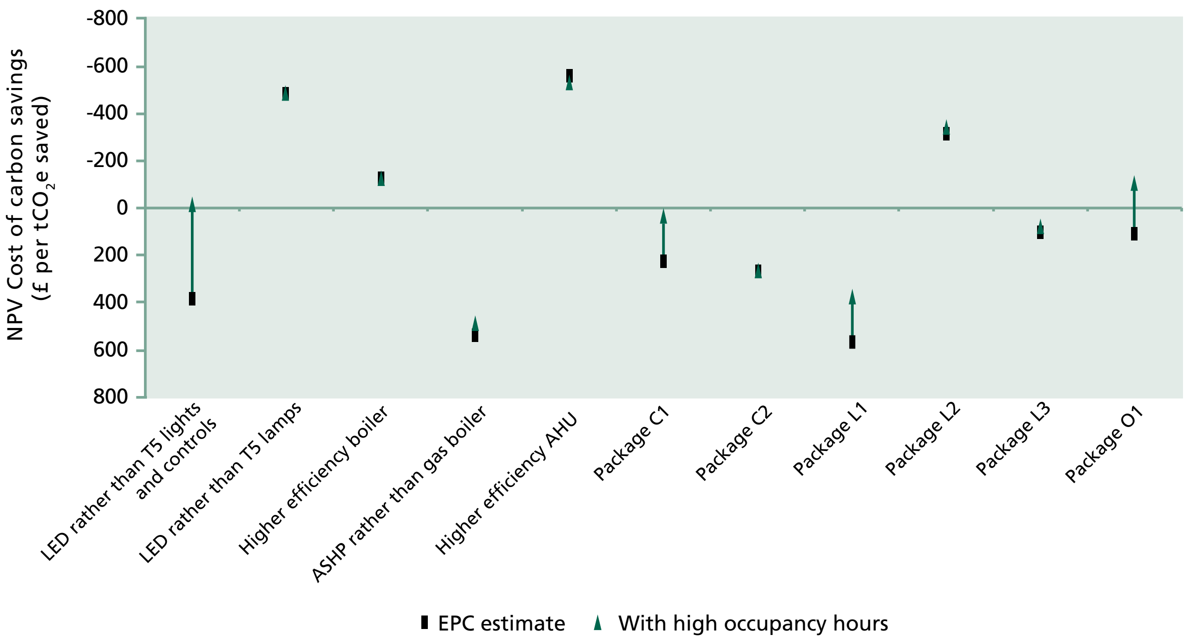


Figure 5.32: Office Three - Cost of carbon reduction compared to 'market standard' alternative measures



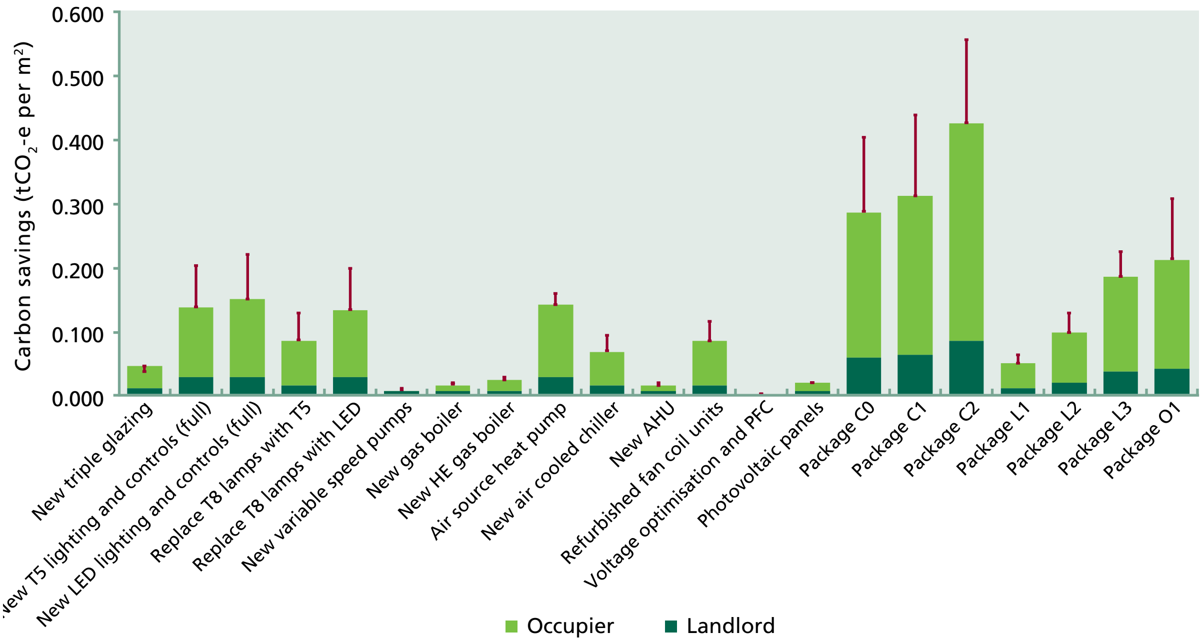
5. OFFICES

Key points

- Lamp replacement, power factor correction and reconditioned fan coils all show a negative cost of carbon (i.e. a financial saving as well as a carbon saving). This is also true of the occupier package O1.
- For measures where there is a net cost to save carbon, this is lowest for boiler upgrades, while for other measures the cost (based on EPC estimates) is above £200 per tonne of CO_2e saved.
- The cost of choosing more energy efficient options, compared to a market standard refurbishment, is also above £200 per tonne CO_2e for all of the packages except L2, L3 and O1.

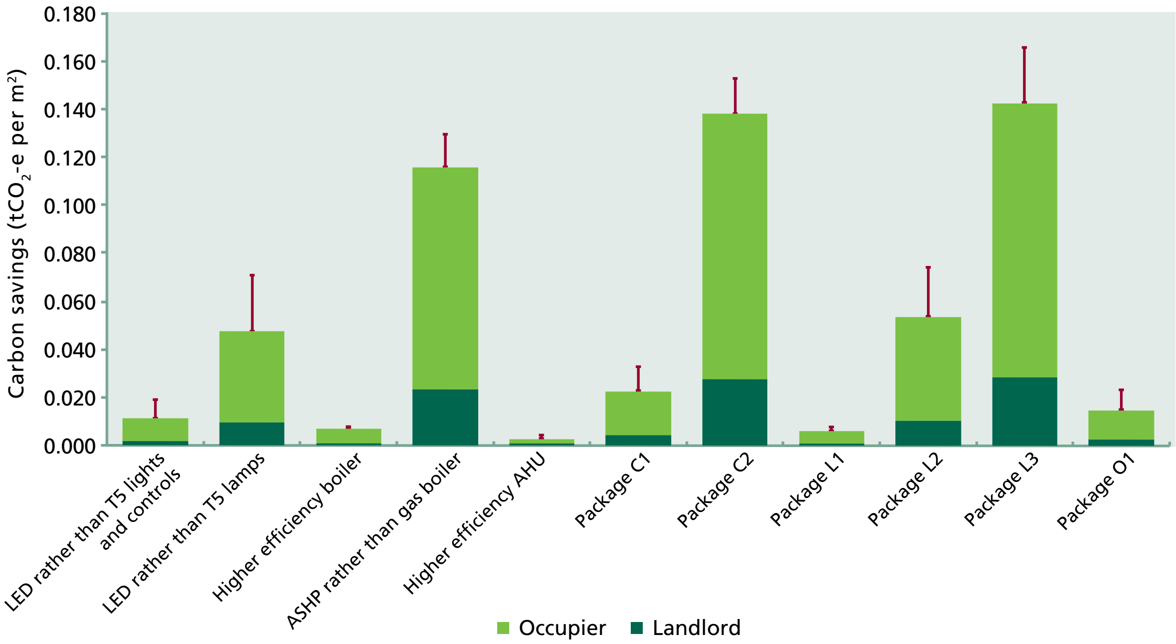
Total carbon saving

Figure 5.33: Office Three - Total carbon saving compared to 'doing nothing'



5. OFFICES

Figure 5.34: Office Three - Carbon saving compared to 'market standard' alternative measures



Key points

- Carbon savings over 15 years are most significant for lighting, ASHP and fan coil improvements. The carbon savings from more efficient lighting are greater than those for Office One because the low energy lights help to reduce the need for cooling in the building, as well as increasing heating demand. Office One is naturally ventilated and, thus, no reduction in cooling demand applies.
- Savings from more efficient boilers are relatively small because the base building already has a reasonably efficient boiler and because the building has a relatively smaller heating load than Office One.
- Although the installation of triple glazing does increase the EPC rating, there is a carbon saving over a longer period. This option does increase overall energy use because of an increase in demand for cooling that is greater than the reduction in demand for heating. The carbon saving is primarily a result of the impact of decarbonisation of the electricity used for cooling.
- The carbon savings associated with a switch to an ASHP for heating and cooling are significant in comparison with the standard approach of installing a 91% efficient boiler. Energy efficient packages including this change (C2 and L3) deliver the greatest increase in carbon savings relative to the market standard alternative.

5. OFFICES

Carbon reduction in comparison to 2017 emissions

Figure 5.35: Office Three - Reduction in carbon emissions (gas and electricity)

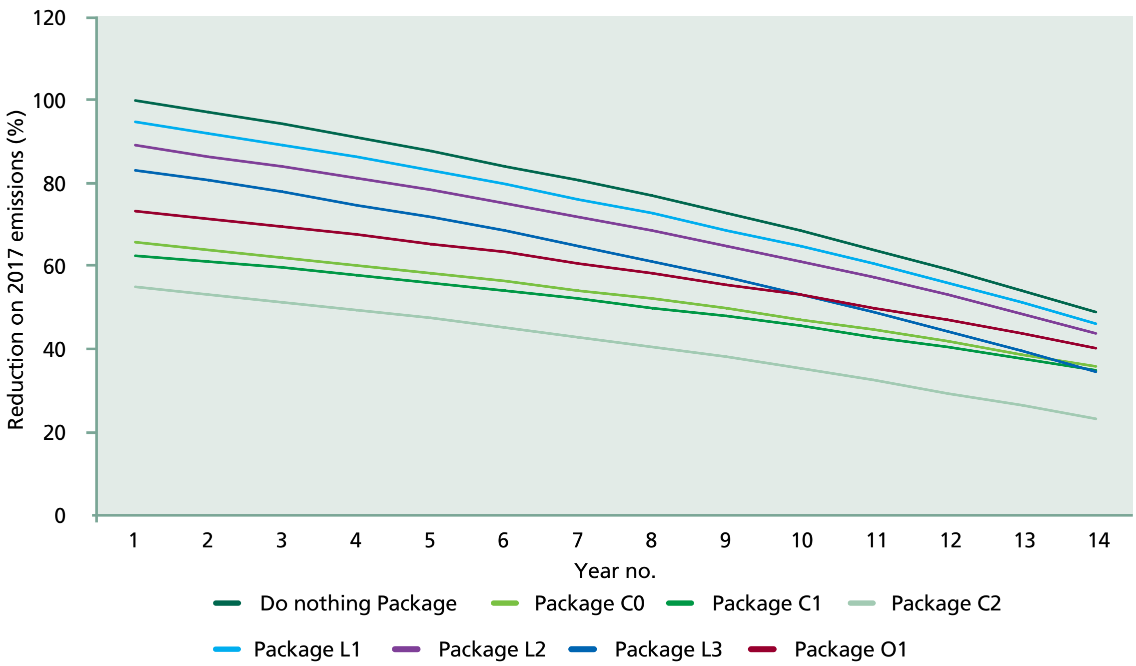
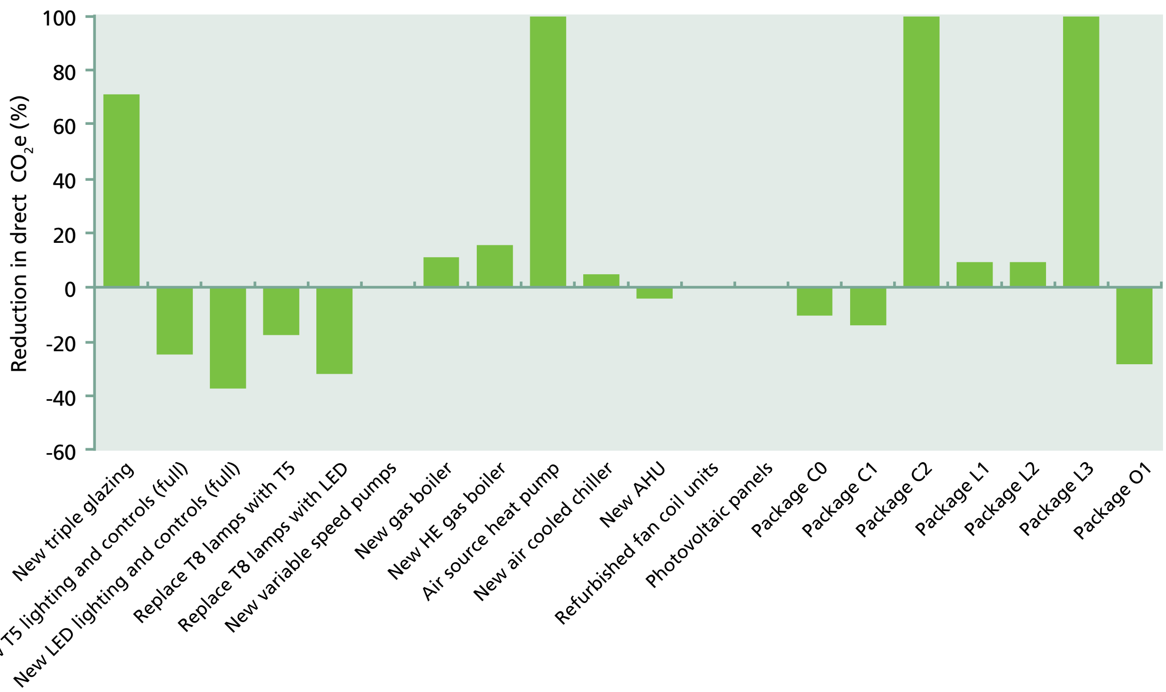


Figure 5.36: Office Three - Reduction in direct emissions (gas only) compared to 2017



5. OFFICES

Key points

- Because of the projected decarbonisation of the electricity supply, all options (including a do nothing option) show reductions in total carbon emissions in the future.
- Each of the improvement packages delivers substantial additional benefit in comparison of the do nothing situation. By 2030, building emissions from package C2 (incl. LED lights and ASHP for heating and cooling) are nearly 80% lower than for the 2017 building and are under half the emissions of the 'do nothing' option.
- Over time, the packages that involve the use of heat pumps (C2 and L3) become more beneficial than those retaining the use of gas boilers.

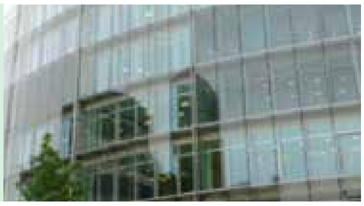
5. OFFICES

5.4 Office Four: Post 2006, Highly Glazed Deep Plan Air-conditioned

Highly glazed deep plan air-conditioned office. Compliant with 2006 Part L Building Regulations.

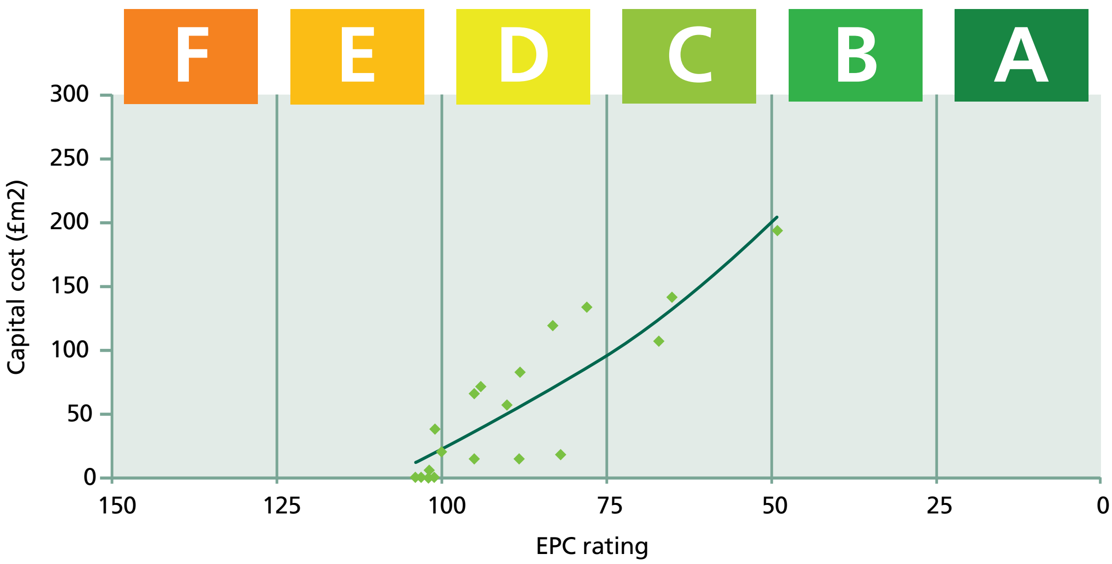
- 5,400m^2
- Air-conditioned
- Deep plan(30m x 30m)
- Storey height (3.7m)

- Glazing 80%, double
- Gas boiler <90% efficient
- T8 light fittings
- Starting EPC = 104 (E)



Improving the EPC rating

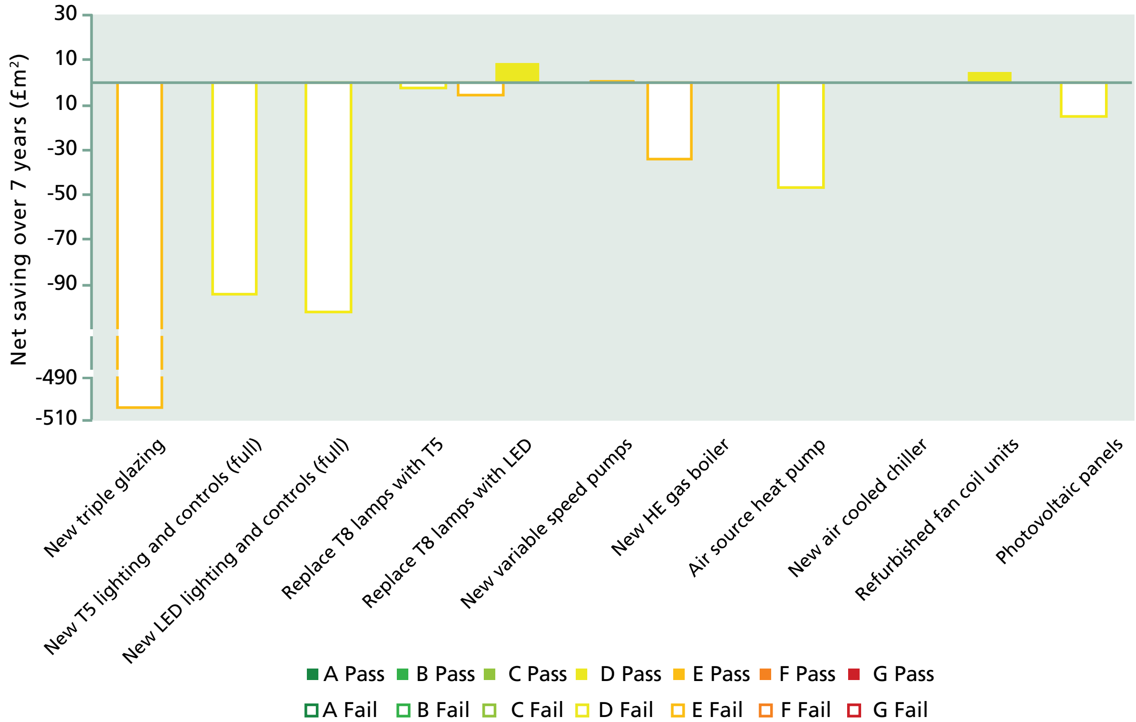
Figure 5.37: Office Four - Capital costs of improving EPC rating



- The existing baseline building has an EPC of E so the landlord is not obligated to try to make improvements to comply with MEES regulations.
- A rating of D could be achieved for less than £20 per m^2 through the installation of new lights (T5 or LED) in existing luminaires.
- An EPC rating of B can be achieved at around £200 per m^2 from investment in LED lights, ASHP and fan coil drives.
- There is a reasonably strong correlation between investment and EPC rating, major outliers above and below the trend line relate to lighting with lamp replacements being more cost effective than other measures and new light systems less cost effective.

5. OFFICES

Figure 5.38: Office Four - Cost effectiveness of measures for MEES compliance



- Installation of triple glazing makes the EPC rating worse because it increases the energy required for cooling.
- All other measures improve the EPC rating of the building to some extent. However, most do not meet the seven year test prescribed by MEES regulations.
- Replacing existing T8 lights with LED tubes result in an undiscounted saving over seven years in comparison to the cost of installation and interest at the BoE base rate. However, the installation of T5 lights does not pass the seven year test.
- Installation of variable speed pumps delivers a small net benefit over seven years.
- Refurbishment of existing fan coils with the installation of EC drive units delivers a net benefit and achieves an EPC of D.

5. OFFICES

Costs and savings over 15 years

Figure 5.39: Office Four - Costs and savings compared 'doing nothing'

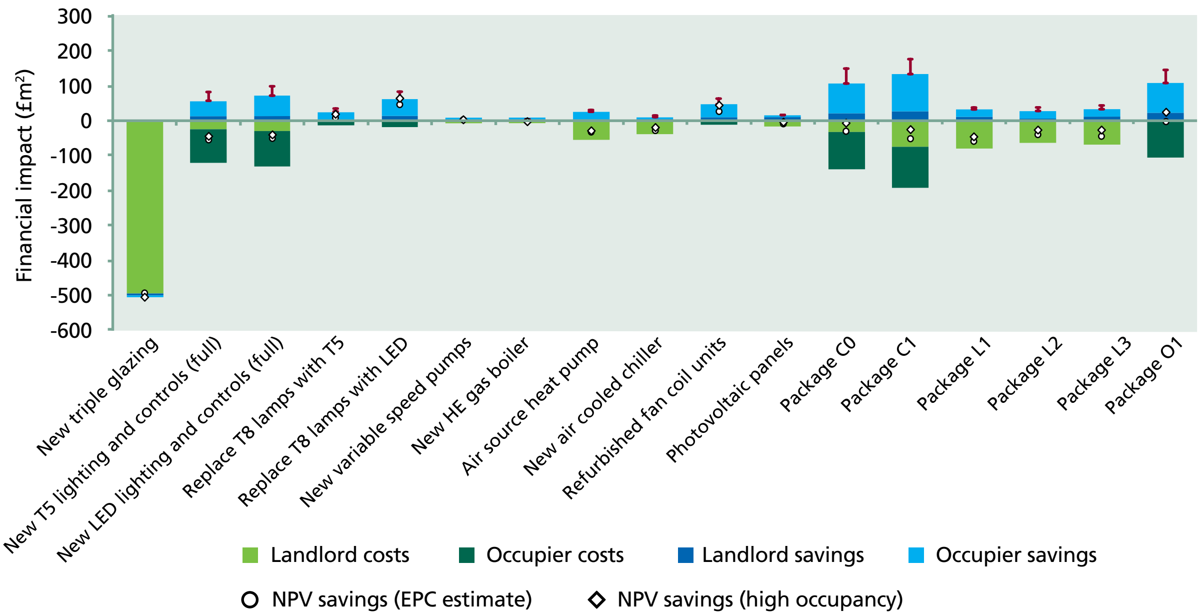
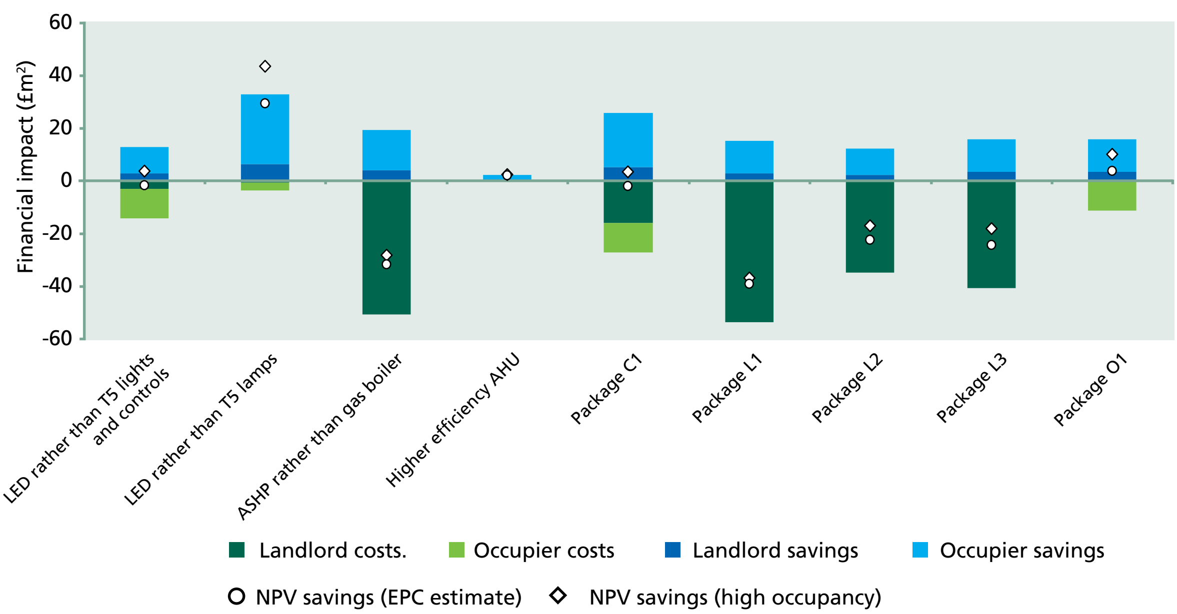


Figure 5.40: Office Four - Costs and savings compared to 'market standard' alternative measures



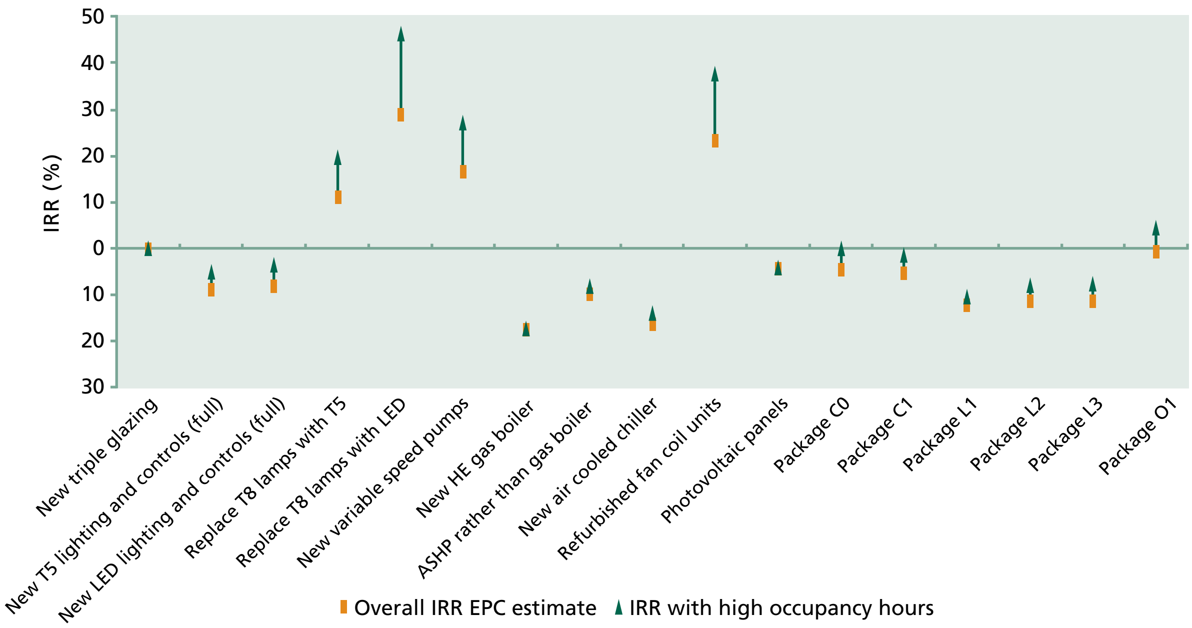
5. OFFICES

Key points

- The installation of triple glazed windows increases energy consumption and associated costs because it increases the amount of space cooling required. This means that this option is more expensive in terms of both capital and operating costs than leaving the original glazing in place.
- Because of the relatively high performance of the base building systems, the biggest financial savings arise from improvements in lighting and in fan coil units, both measures that have the most significant impact when applied to the occupied/let space in the building.
- Installation of triple glazing is a very expensive option and it results in additional energy costs to provide the necessary cooling.
- There is a net benefit from specifying more efficient lighting and also for package O1.

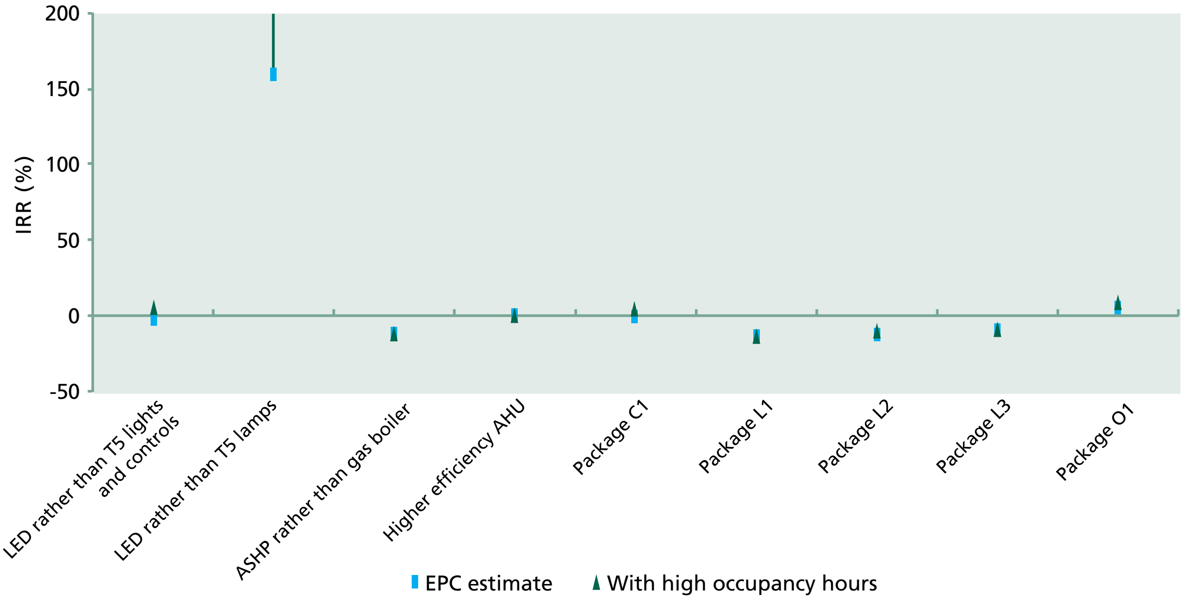
IRR of measures

Figure 5.41: Office Four - Internal Rate of Return compared to 'doing nothing'



5. OFFICES

Figure 5.42: Office Four - Internal Rate of Return compared to 'market standard' alternative measures



Key points

- Replacement of lamps within existing luminaire delivers a very strong IRR of nearly 30% for LED systems but only around 10% for T5 tubes. Replacement of the whole lighting and control system does not achieve a positive IRR but should deliver substantial quality enhancements to the space.
- Refurbishment of fan coils to include EC drive units delivers a good return of over 20%. Similar returns are available from installation of variable speed pumps, albeit the total sum of the energy saving from this option is quite small.
- The returns for more energy efficient packages of measures are typically negative for whole building (i.e. combined) or landlord only activities, but are positive for occupier areas (as a result of efficiencies in lighting).

5. OFFICES

Cost of carbon reduction

Figure 5.43: Office Four - Cost of carbon reduction compared to 'doing nothing'

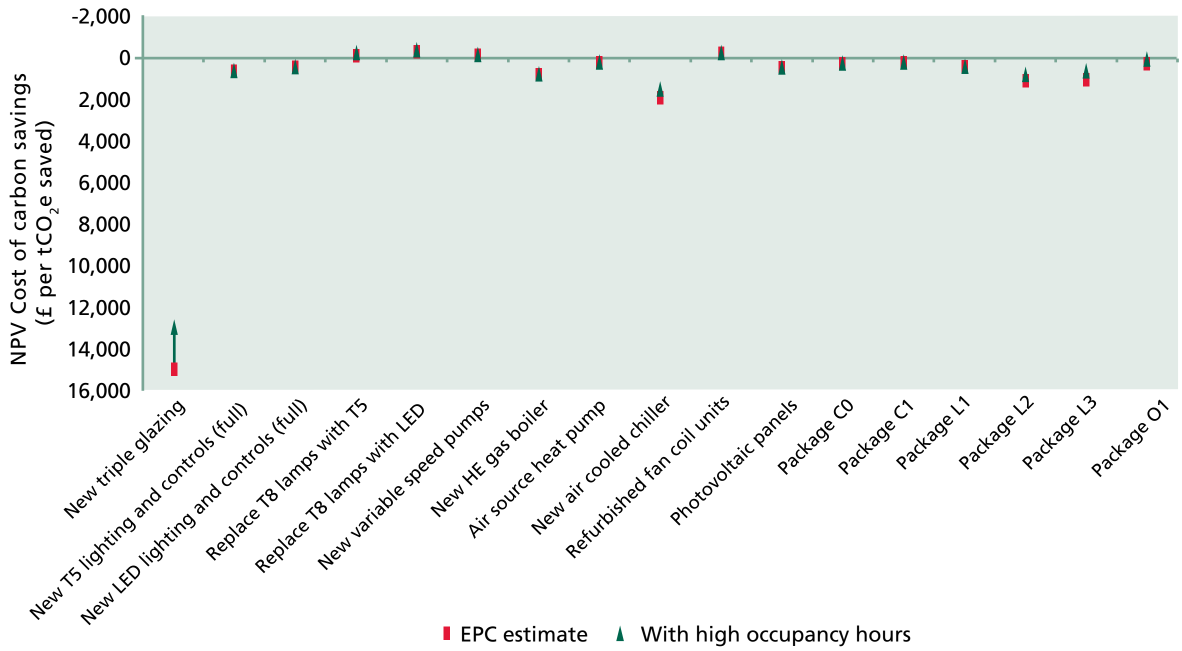
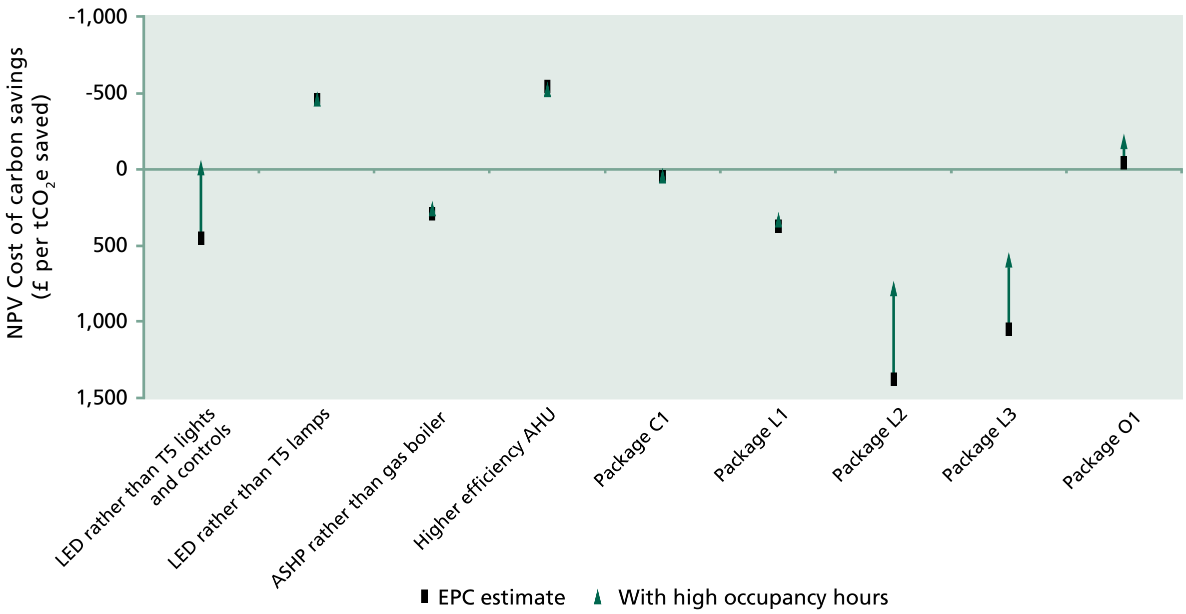


Figure 5.44: Office Four - Cost of carbon reduction compared to 'market standard' alternative measures



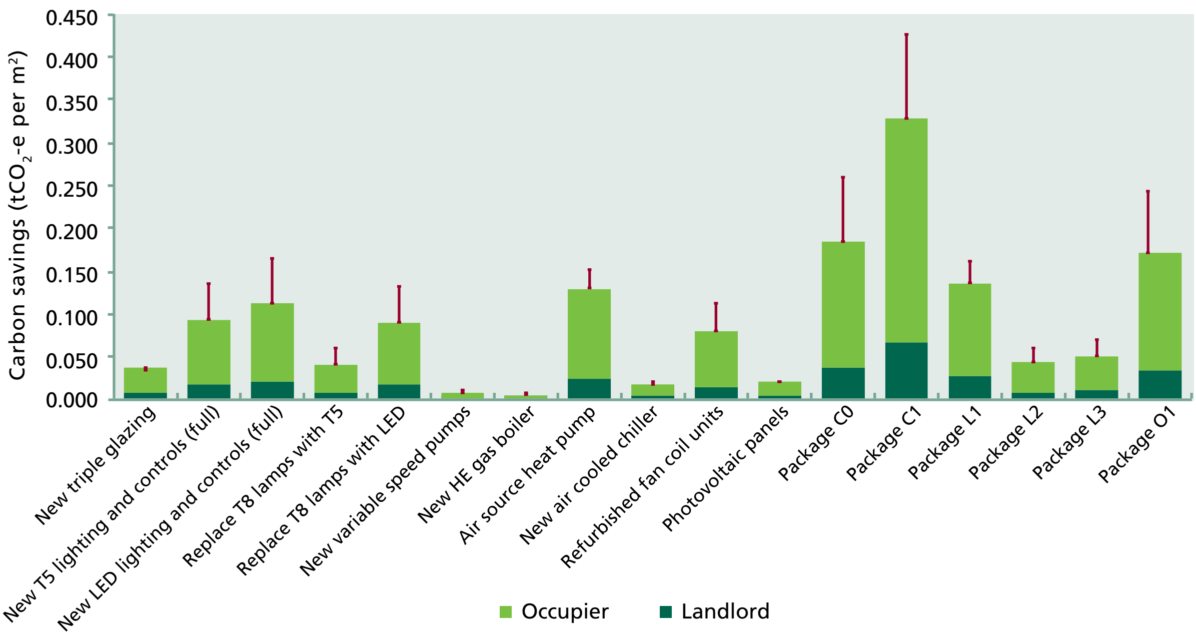
5. OFFICES

Key points

- In comparison to doing nothing, lamp replacement and fan coil upgrades show a negative cost of carbon saving (i.e. they are less expensive and also save carbon). Other options show costs of carbon savings that are over £200 per tonne CO_2e in the case of new chillers these costs are very high indeed, mainly a result of the relative efficiency of the base systems in the building.
- In all instances the likely 'actual' cost of carbon saving is lower than that which might be expected by an EPC assessment.

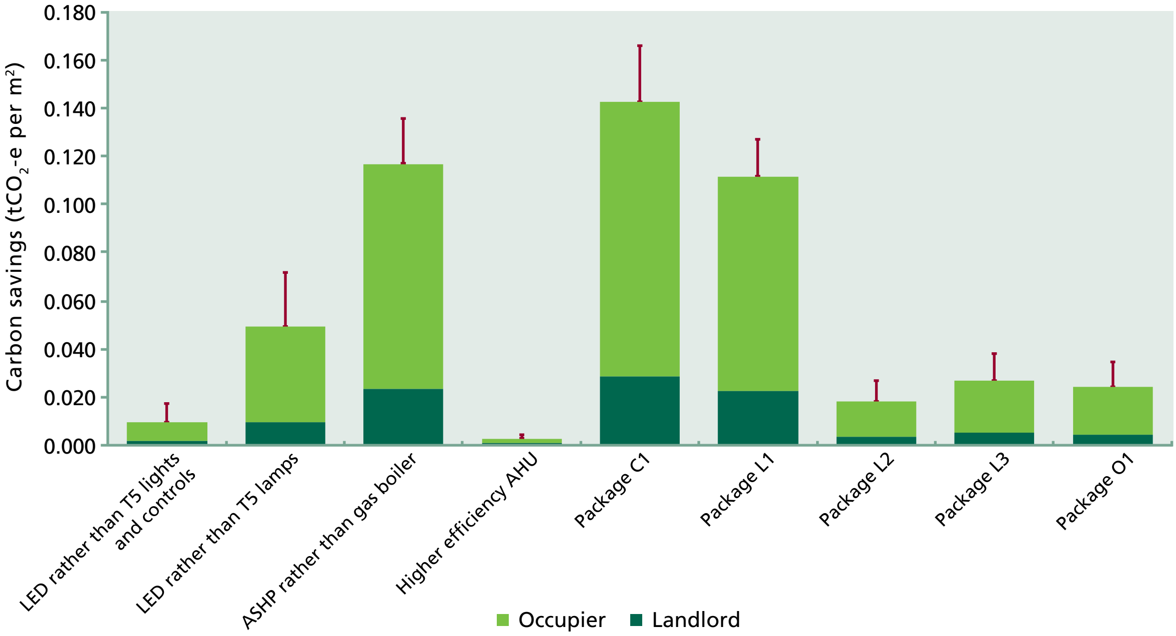
Total carbon saving

Figure 5.45: Office Four - Total carbon saving compared to 'doing nothing'



5. OFFICES

Figure 5.46: Office Four - Carbon saving compared to 'market standard' alternative measures



Key points

- Carbon savings over 15 years are most significant for lighting and fan coil improvements, and are comparatively small for upgrades to central plant other than those linked to a switch from gas to electric powered heating.
- Because most of the energy and carbon saving opportunities are linked to lighting and fan coil units, the majority of the improvement potential is linked to Occupier rather than Landlord.
- The carbon savings from more efficient lighting are greater than those for Office One because the low energy lights help to reduce the need for cooling in the building as well as increasing heating demand. Office One is naturally ventilated and so no reduction in cooling demand applies.
- Savings from more efficient boilers are relatively small because the base building already has a reasonably efficient boiler.
- Although the installation of triple glazing does increase (worsen) the EPC rating there is a carbon saving over a longer period. This option does increase overall energy use because of an increase in demand for cooling that is greater than the reduction in demand for heating. The carbon saving is primarily a result of the impact of decarbonisation of the electricity used for cooling.

5. OFFICES

Carbon reduction in comparison to 2017 emissions

Figure 5.47: Office Four - Reduction in carbon emissions (gas and electricity)

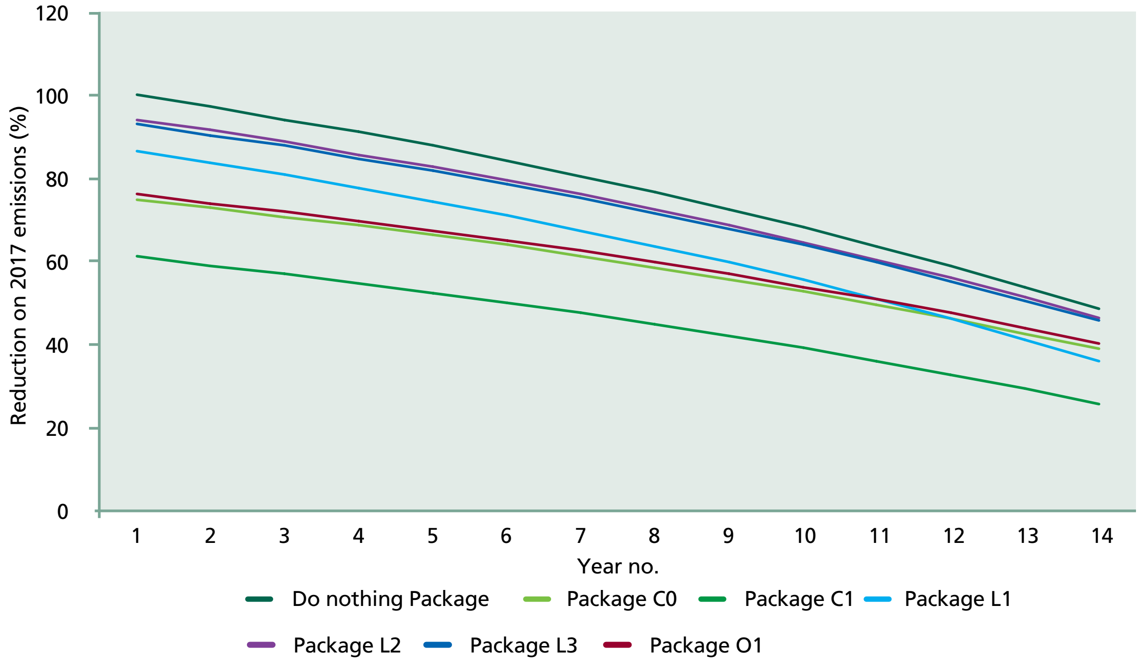
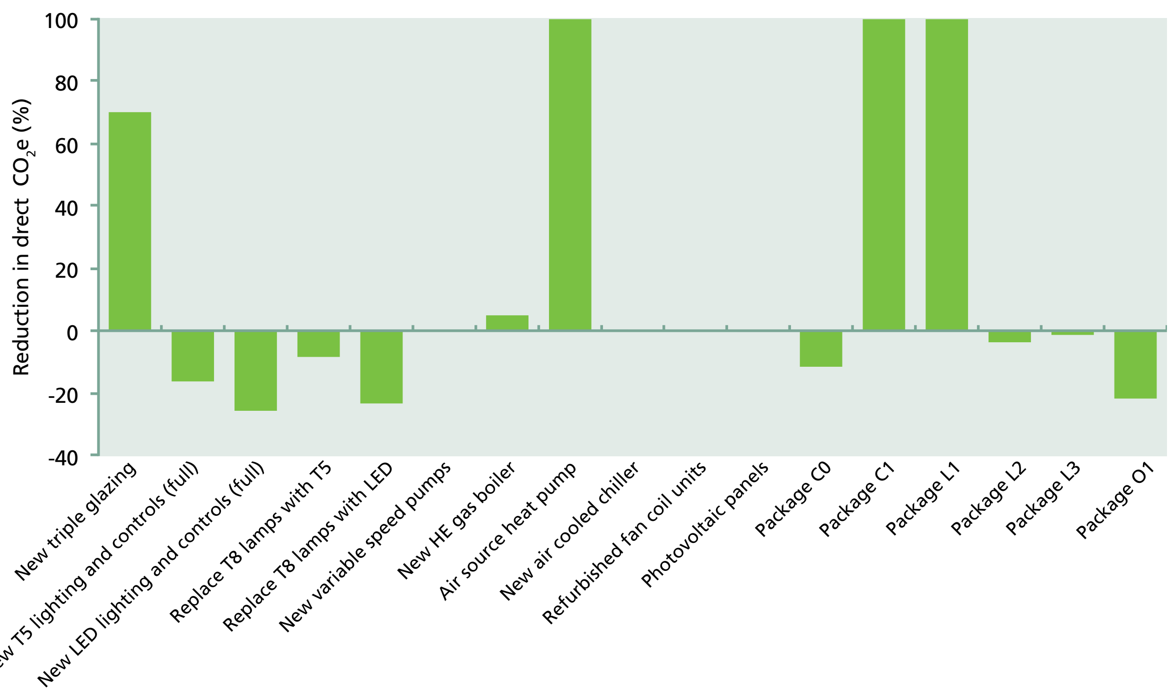


Figure 5.48: Office Four - Reduction in direct emissions (gas only) compared to 2017



5. OFFICES

Key points

- Because of the projected decarbonisation of the electricity supply all options (including a do nothing option) show reductions in total carbon emissions in the future.
- Each of the improvement packages delivers substantial additional benefit in comparison of the do nothing situation. By 2030, building emissions from package C1 (incl. LED lights and ASHP for heating and cooling) are nearly 80% lower than for the 2017 baseline building and are under half the emissions of the ‘do nothing’ option.
- Over time, the packages that involve the use of heat pumps (C2 and L3) become more beneficial than those retaining the use of gas boilers.

5. OFFICES

5.5 Summary of Office Findings

EPC ratings

- It is possible to 'cost effectively' improve those buildings with an EPC of below E through the replacement of lamps in existing luminaires or, potentially, replacement of boilers or other measures, such as installation of variable speed pumps.

Cost effective energy savings

- From a cost effectiveness and energy use perspective, lighting is the most significant improvement for all buildings. For older, naturally ventilated buildings, installation of a new boiler also delivers a good return. For air-conditioned buildings, upgrading fan coil drives (where present) are the most important measure.
- For most buildings there is a strong correlation between the level of investment and improvement in EPC rating. Major outliers from the mean cost curve are:
  - replacement of lamps with LED technology and reconditioning fan coils (where present) with EC drives, both of which are substantially more cost effective than other options; and
  - upgrading glazing systems; these are typically far less cost effective and, in more highly glazed AC buildings, even have a negative effect on energy use, cost and emissions.
- For the naturally ventilated building, the installation of an ASHP is expensive relative to a new gas boiler; however, payments from the renewable heat incentive mean that, over 15 years, the net cost is similar, albeit at a lower IRR. However, the carbon savings over 15 years of installing an ASHP are nearly double that of even a highly efficient gas boiler.
- The cost of fully replacing the lighting and control system are not recovered purely through energy savings; however, the new lighting system could be expected to offer a higher quality internal environment in addition to energy savings.
- For newer buildings (e.g. Office Four) the major opportunities for improvement are linked to lighting and drive units for fan coils, as these are areas that have developed most substantially in the last decade.

Carbon savings

- Even under a 'do nothing' scenario, carbon emissions reduce in each building, although substantial additional savings are available through use of existing technology so that, by 2030, emissions could be close to 80% lower than those in the 2017 baseline buildings.
- Measures with the most significant impact on direct emissions are fabric improvements (e.g. new glazing), more efficient boilers and, most significantly, the adoption of electric heating (ASHP's). The installation of efficient lighting tends to increase direct emissions in all buildings because they are cooler and thereby increase heating demand, while reducing cooling demand. Heating is typically provided by gas (a source of direct emissions), while cooling is provided by electricity (indirect emissions). This should on no account discourage the adoption of energy efficient lighting, which is both cost and carbon efficient. However, it does demonstrate that, at some point, landlords will need to go beyond these measures and address the heating load or supply of heat to buildings.
- Significant long-term carbon savings are linked to a switch away from gas-based heating to electric heating systems.
- Carbon savings from lighting improvements are greater for AC buildings (or naturally ventilated buildings using heat pumps for heating) because the reduction in heat output from the more efficient lighting increases heating demand. In financial terms, the use of energy efficient lighting results in significant and sustained reductions in running costs.

6. RETAIL WAREHOUSE

Energy consumption in retail buildings (use class A1) is high for two reasons. Firstly, considerable energy is consumed by high levels of lighting for product display. This leads to high 'heat gains' from the waste heat produced by the lighting. This heat load must then be reduced by additional energy use for cooling. Use of efficient lighting systems can make a major energy efficiency contribution, therefore, by reducing direct energy use and also the demand for cooling.

Retail buildings are diverse in terms of their physical characteristics (including the type of air conditioning system installed) and also the extent to which a landlord can influence energy consumption. Buildings on retail parks are constructed and let to a shell specification. The shell construction of these units is very similar to a modern warehouse, but with an attractive glazed entrance. Frequently, a landlord becomes responsible for building services installed by a previous occupier whose tenancy has expired. Where this is the case, a landlord needs to understand the energy rating of the space with its pre-existing fit out to make suitable decisions about the preparation and marketing of the space.

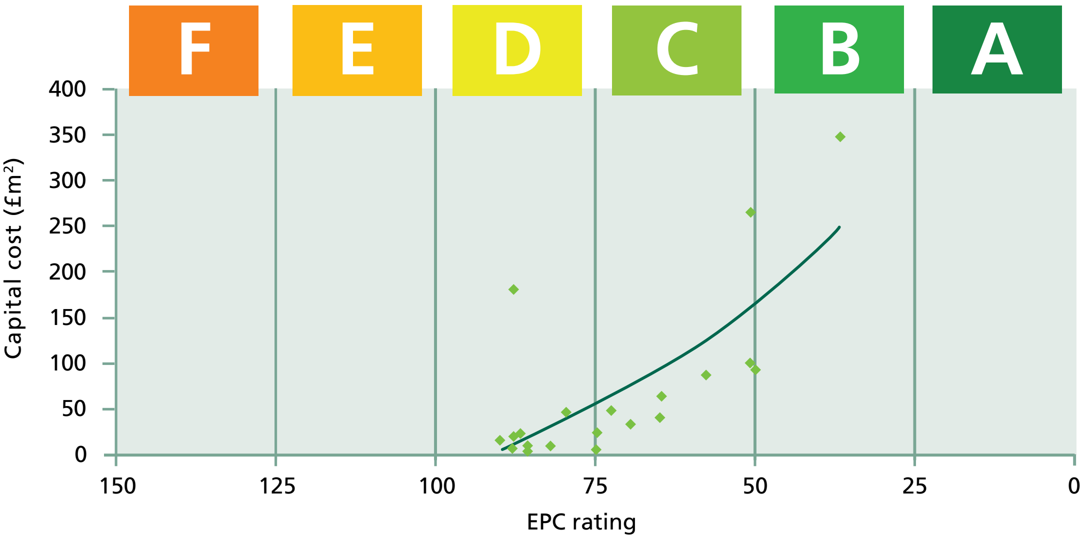
6.1 Retail Park Building

Single storey with lighting, heating and air conditioning. Limited windows. Office and warehouse space included. Compliant with 1990 Building Regulations.

- Sales area 4,500m^2
- Office 600m^2
- Warehouse 500m^2
- Air-conditioned
- Deep plan(30m x 30m)
- Storey height (4m)
- Glazing office area only
- Gas boiler 65% efficient
- T8 light fittings
- Starting EPC = 90 (D)

Improving the EPC rating

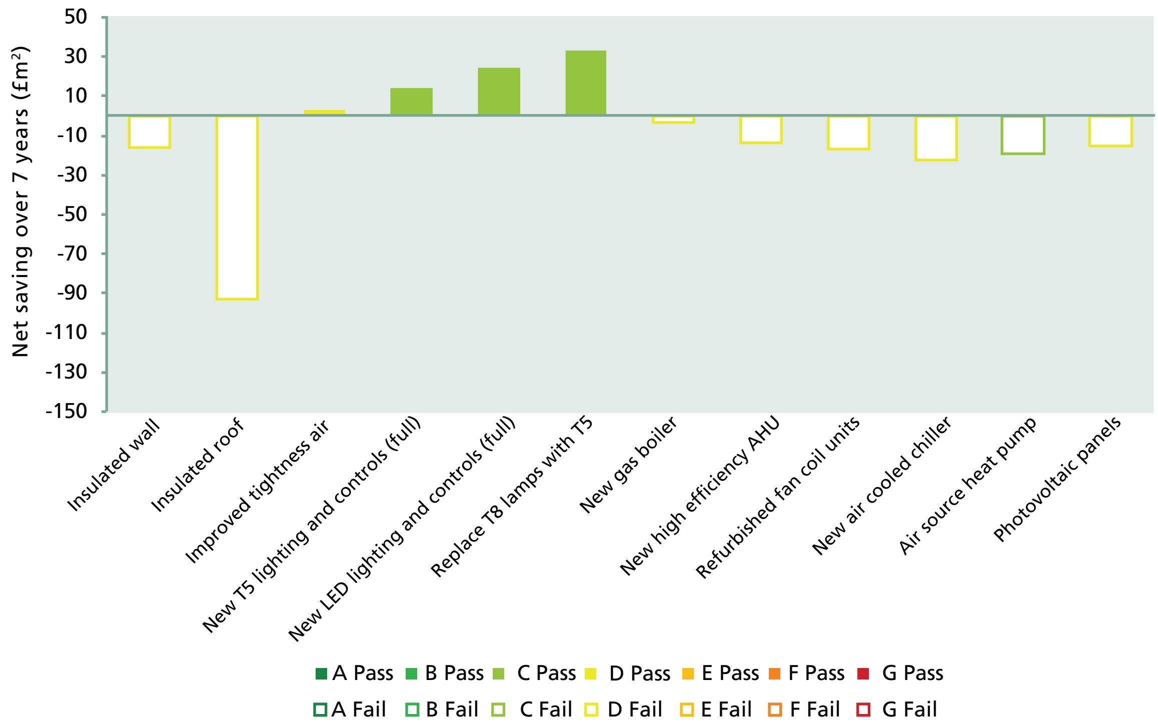
Figure 6.1: Capital costs of improving EPC rating



6. RETAIL WAREHOUSE

- The existing baseline building has an EPC of D; hence, the landlord is not obligated to make improvements to comply with MEES regulations.
- A rating of C could be achieved for less than £10 per m^2 through the installation of new lights (T5) in existing luminaires.
- An EPC rating of B can be achieved at around £100 per m^2 from investment in LED lights and ASHP or LED, new boilers, chillers and AHU. Investment in a package involving LED, boilers, chillers, new AHU and fan coil drives, plus improvements to roof insulation and air tightness could deliver an EPC score of 37 (B) at a cost of c.£350 per m^2.
- There is a reasonably strong correlation between investment and EPC rating; major outliers above and below the trend line relate to lighting with lamp replacements being more cost effective than other measures and roof insulation less cost effective.

Figure 6.2: Cost effectiveness of measures for MEES compliance

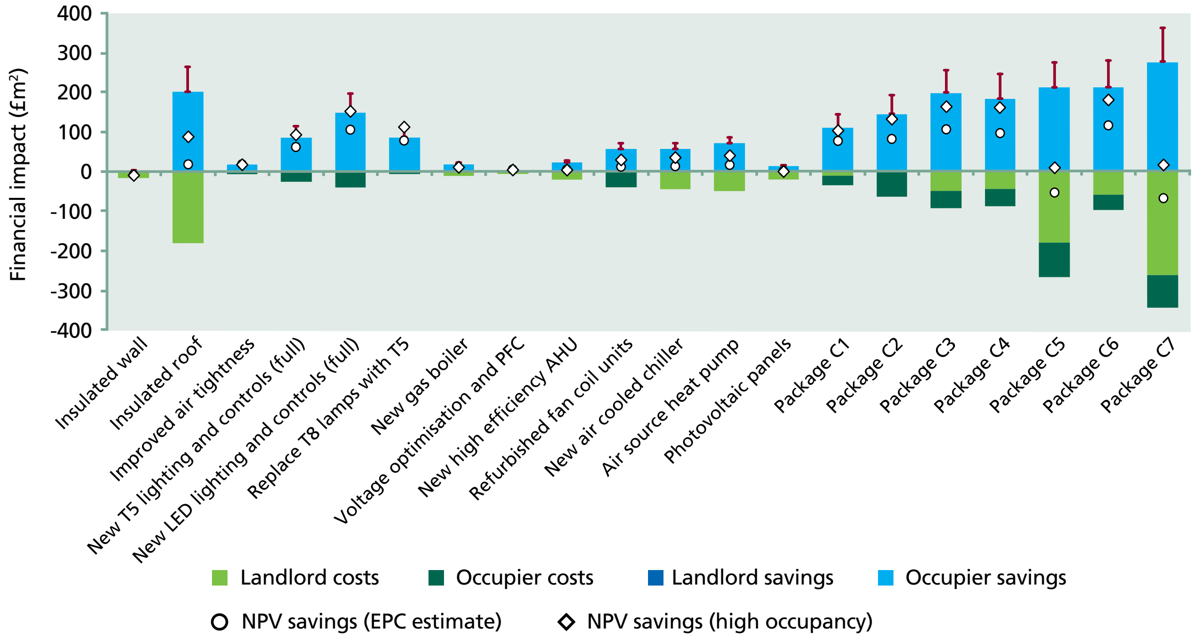


- Air tightness and lighting improvements pass the seven year test, with the lighting improvements also improving the EPC from its original D rating to C.

6. RETAIL WAREHOUSE

Costs and savings over 15 years

Figure 6.3: Costs and savings compared to 'doing nothing'



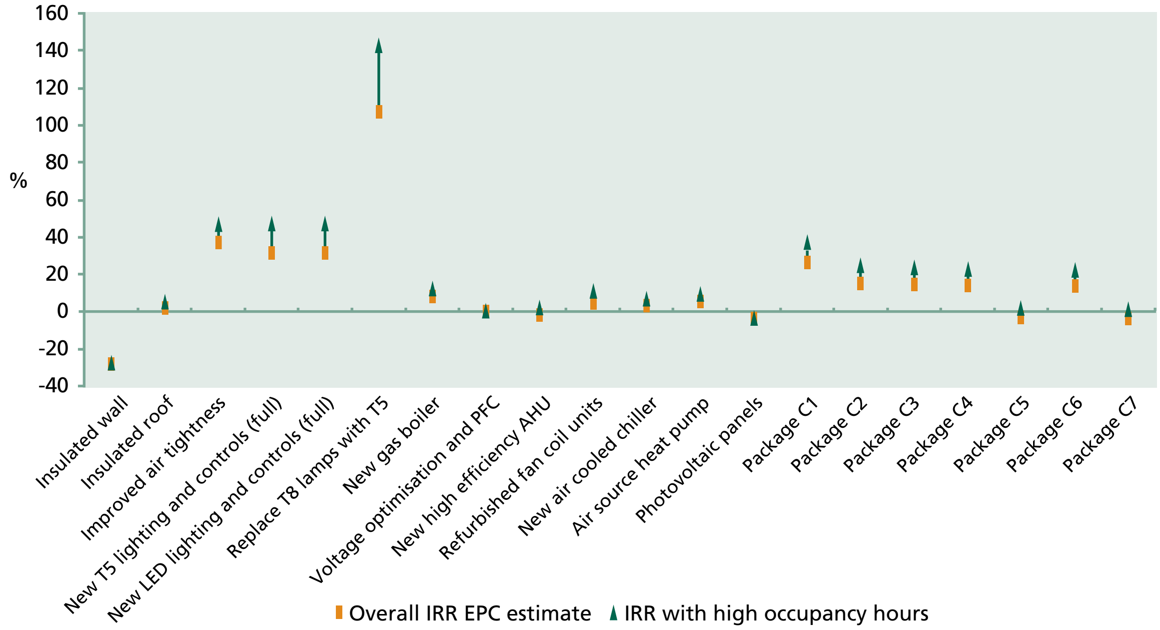
Key points

- Most of the improvement measures deliver a net saving over 15 years, especialy when taking in to consideration the higher estimated savings associated with increased hours of occupation (as might be expected for retail buildings).
- Unlike office buildings, lighting replacement delivers significant net savings; this is partly a reflection of the lower lighting density of these fittings in comparison to office space.
- The walls of the example building were already reasonably well insulated (U value of 0.45 Wm^2K) implying limited saving from improving this further. Additional insulation to the roof space (to 0.25 Wm^2K) does deliver substantial further energy savings, however, in part because of the large roof to floor area ratio in the single storey sales area.

6. RETAIL WAREHOUSE

IRR of measures

Figure 6.4: Internal Rate of Return compared to 'doing nothing'



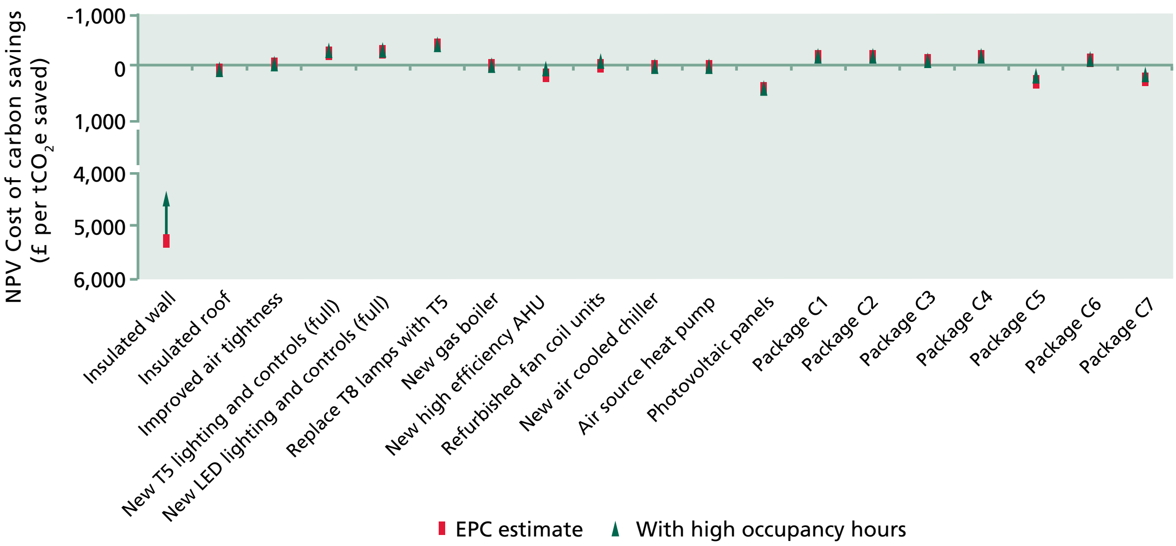
Key points

- Lighting upgrades and also packages C1 – C4 and C6 (packages of lighting and services improvements) show IRRs of 15% or above (20% or above if the estimated additional savings from additional operating hours are taken in to account). Packages containing fabric improvements (C5 and C7) do not show a positive IRR.

6. RETAIL WAREHOUSE

Cost of carbon reduction

Figure 6.5: Cost of carbon reduction compared to 'doing nothing'



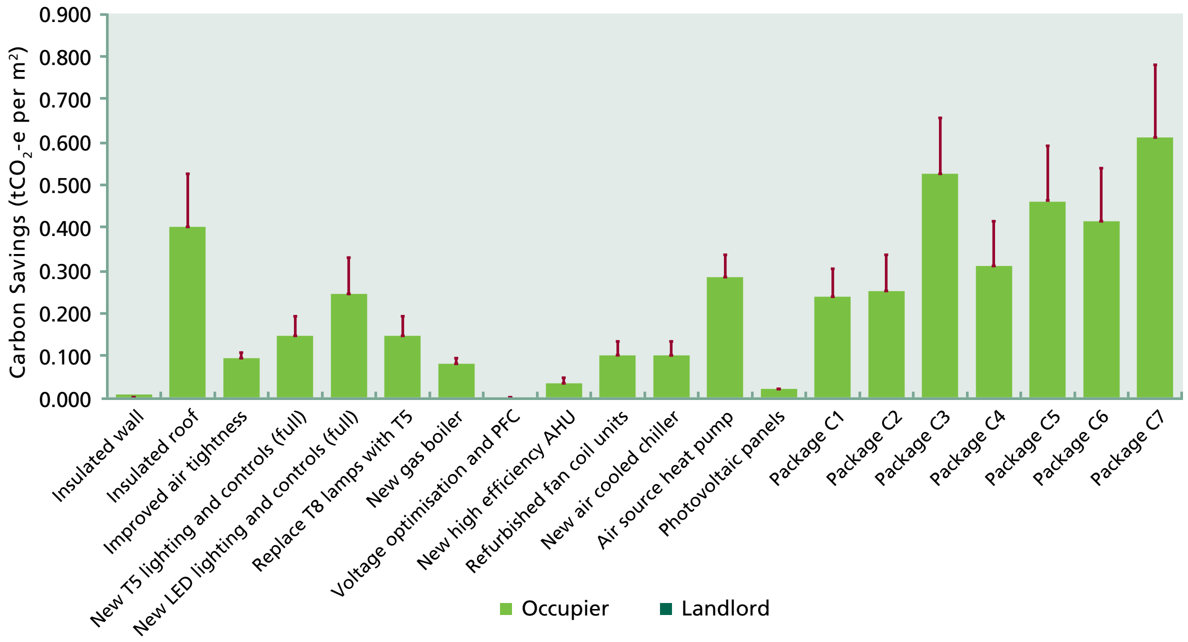
Key points

- Many of the improvement measures have a negative cost of carbon saving (i.e. they save both cost and carbon over 15 years). Again, lighting improvements are the most cost effective in this building, as are packages that contain these measures.
- Insulation to walls is a very ineffective measure, partially because the existing walls already have a reasonable level of insulation.

6. RETAIL WAREHOUSE

Total carbon saving

Figure 6.6: Total carbon saving compared to 'doing nothing'



Key points

- The most significant carbon savings over 15 years are associated with roof insulation, installation of an ASHP and of LED lights.
- Wall insulation delivers negligible overall savings, while the savings from roof insulation are substantial.

6. RETAIL WAREHOUSE

Carbon reduction in comparison to 2017 emissions

Figure 6.7: Reduction in carbon emissions (gas and electricity)

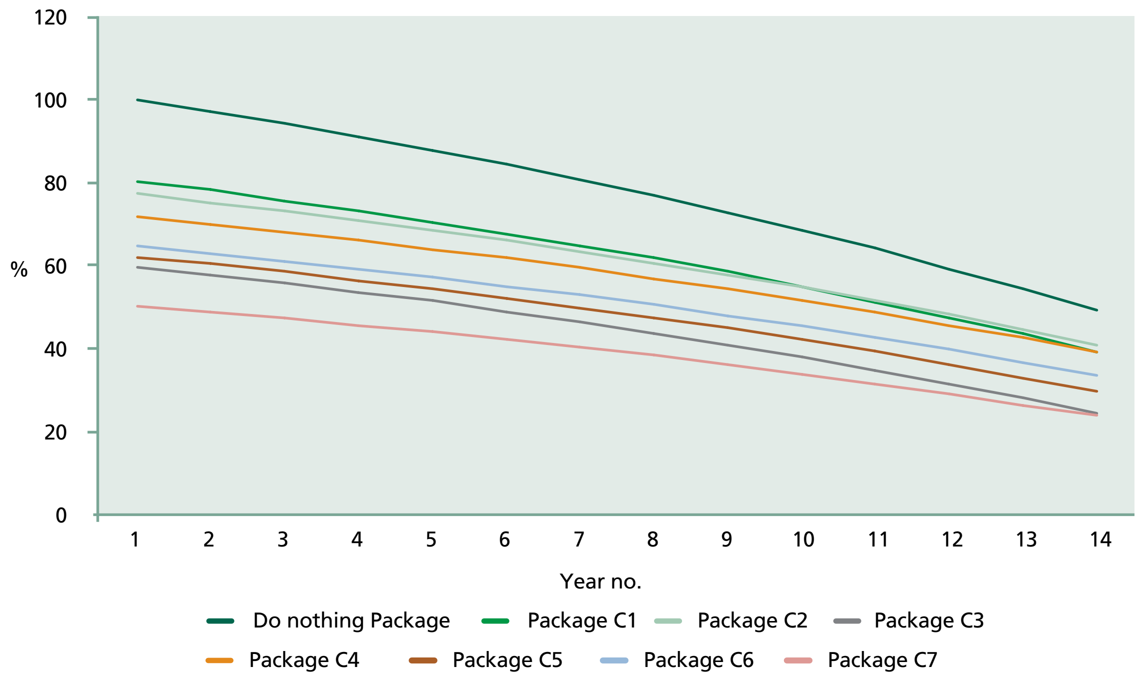
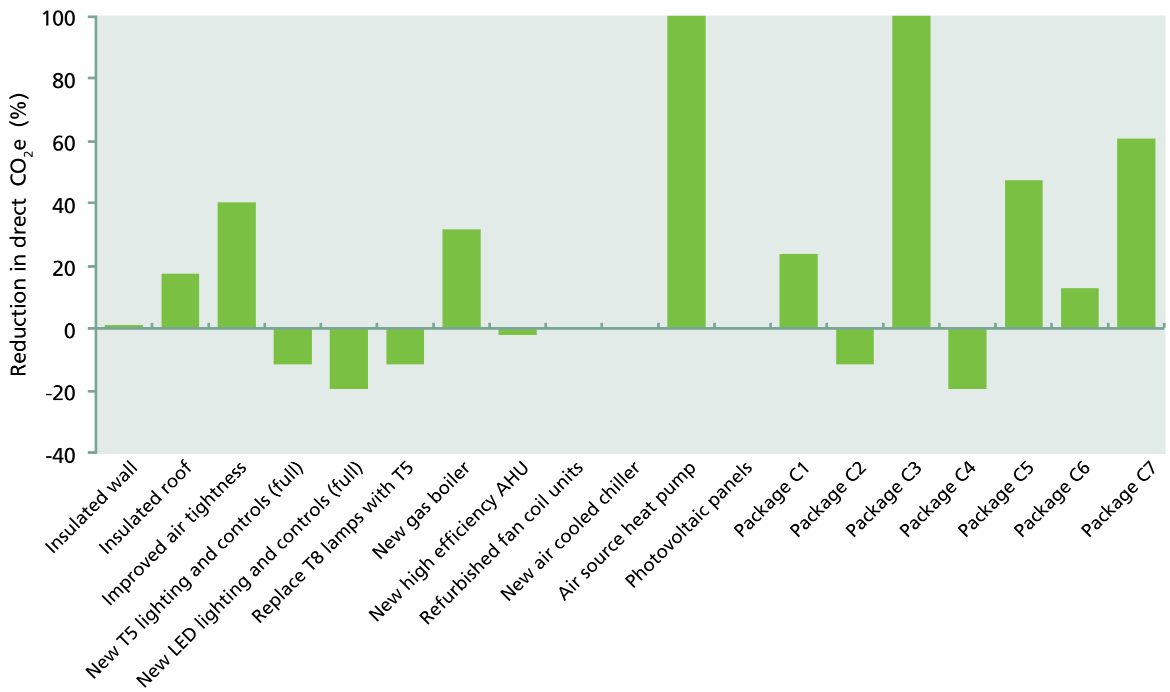


Figure 6.8: Reduction in direct emissions (gas only) compared to 2017



6. RETAIL WAREHOUSE

Key points

- As an air-conditioned building, overall 2017 emissions are dominated by electricity consumption; these emissions reduce substantially (by c.50%) by 2030, even if no active measures are taken to improve efficiency.
- Carbon savings associated with package C3 (which includes LED lighting and an ASHP) become more significant over time and, by 2030, approach those of package C7, which includes both fabric improvements and boiler, chiller, LED lighting and other measures, and is over three times as expensive.
- Switching to ASHPs for heating (and cooling) provides the largest reduction in direct emissions; however, enhanced air tightness also delivers savings of over 40% – and would be over 50% if paired with a new gas boiler.

6.2 Summary of Retail Warehouse Findings

It is possible to achieve an EPC of B at less than £100 per m^2 through investment in improved lighting building services. These measures have an IRR of 15-20% and deliver net savings of £100 to over £150 m^2 over 15 years.

Even though the base building example has a reasonably efficient D rating, it is possible to make improvements, to achieve a C rating, that have a simple payback of less than seven years by improving lighting efficiency. Net savings of £20 to £35 per m^2 over this period are achievable through luminaire or lamp replacement. Over 15 years, the IRR from these measures is more than 30%.

The most significant individual carbon saving opportunities for this building are from roof insulation and installation of an ASHP for heating and cooling. However, the financial returns from these options are not attractive.

7. INDUSTRIAL

The manufacturing or trade processes carried out within industrial buildings often account for the vast majority of energy consumed by the building. In general, for industrial space flexible enough to accommodate a variety of industrial process, the landlord is likely to offer non-task specific lighting and some background space heating (e.g. gas fired radiant heaters or air blowers) as part of the letting arrangement. Where the manufacturing process is more intensive and complex, factories will be built as a shell for the manufacturer to wholly fit out or be a bespoke build, by the manufacturer, and owner-occupied or sold on a sale and leaseback arrangement. Accordingly, improving the thermal performance of general light industrial buildings, lighting efficiency and heating systems are the main opportunities for landlords. Given that factory buildings are typically single storey and have a large footprint, maximising the use of natural daylight is a key opportunity for reducing energy consumption (providing there are windows to facilitate this).

Unlike factories, warehouses and distribution centres (use class B8) are not energy intensive due to the absence of any manufacturing process in the building. General warehouse lighting is part of the landlord's base specification and is the main consumer of energy. In older facilities, background heating may be provided by the landlord and, therefore, presents an opportunity to improve energy efficiency. Large modern warehouses have a particularly high level of energy consumption associated with lighting; consequently, lighting efficiency and utilising natural light are key considerations. Where cold storage is present, this can be a substantial unregulated source of energy consumption.

7.1 Industrial building

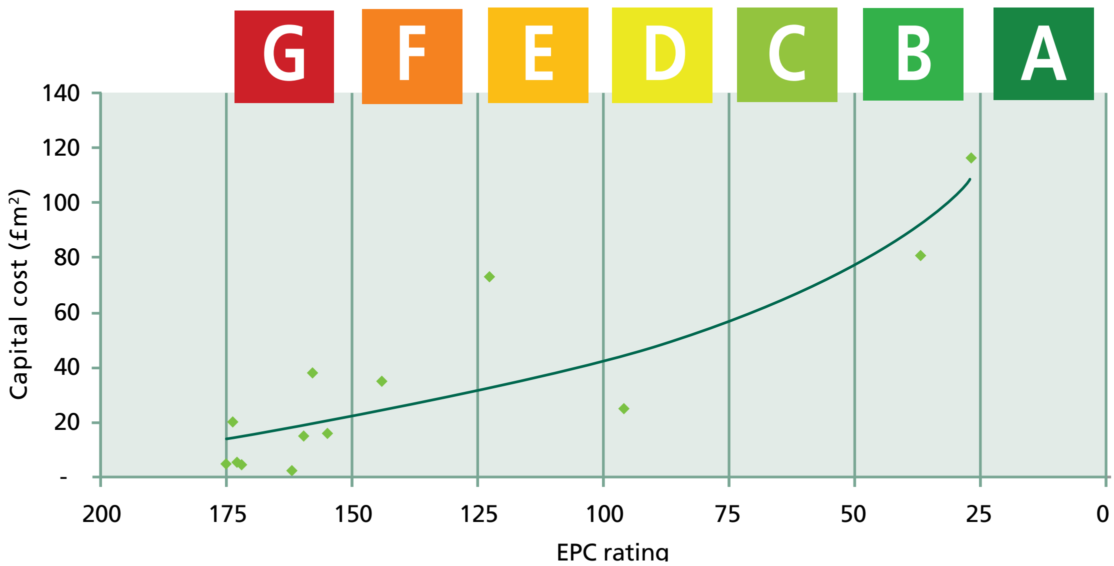
Single storey with lighting and heating. Limited windows or roof lights.
Offices included. Compliant with 1990 Part L Building Regulations.

- Industrial space 4,500m^2 (75m x 60m)
- Office 600m^2 (20m x 15m)
- Natural ventilation and heating only in warehouse, air conditioning in office area
- Storey height (4m)
- Single glazing office area only
- Uninsulated external walls and roof
- Gas boiler 65% efficient
- T8 and metal halide light fittings
- Starting EPC = 178 (G)

7. INDUSTRIAL

Improving the EPC rating

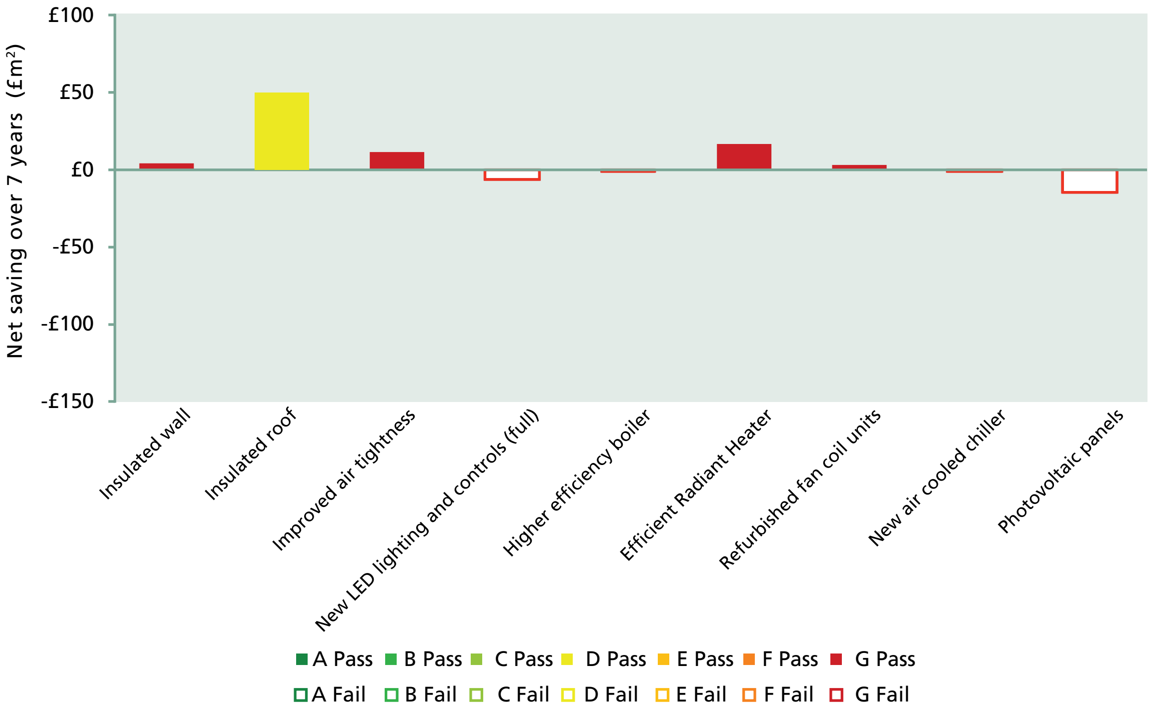
Figure 7.1: Capital costs of improving EPC rating



- The existing baseline building has an EPC of G so the landlord is obligated to try to make improvements to comply with MEES regulations.
- Inexpensive roof insulation achieves an EPC of D at c. £25 per m^2; packages containing this measure also achieve EPC B ratings for £80 to £120 per m^2.
- Without improvement in the building fabric (i.e. roof insulation), it is difficult to achieve more than a high E rating even with packages of measures.

7. INDUSTRIAL

Figure 7.2: Cost effectiveness of measures for MEES compliance

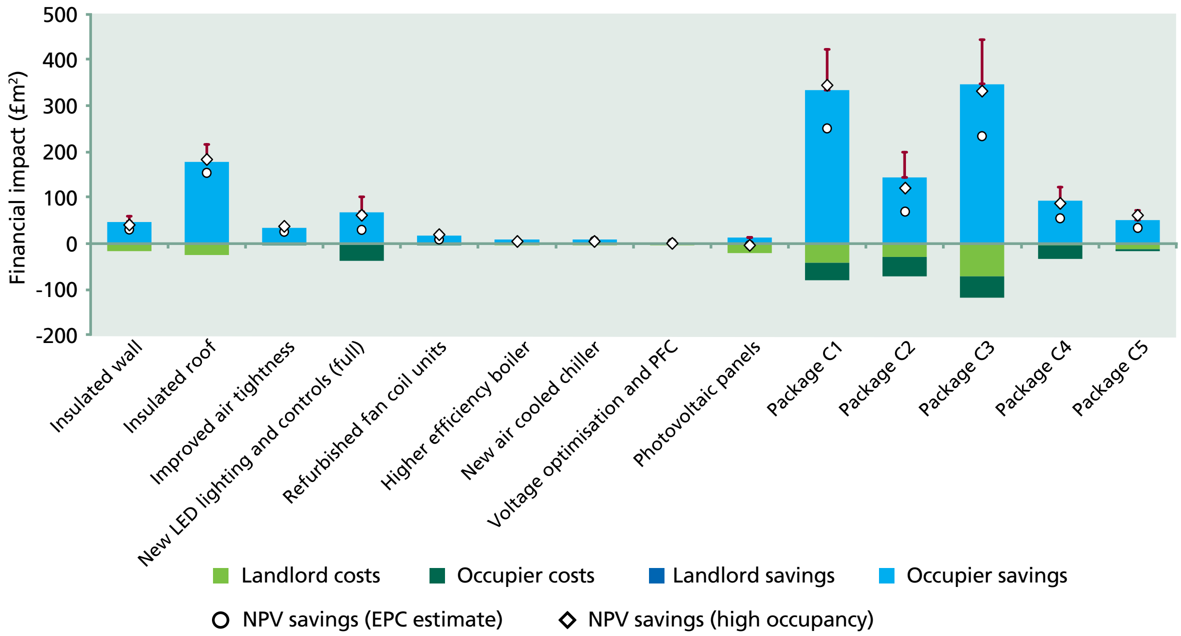


- In contrast to other the buildings assessed, several of the fabric energy efficiency measures pass the seven year test but only roof insulation delivers sufficient savings to improve the building's EPC to above an E or above.
- Improvements to the roof are both cost effective and impactful in improving the building's EPC rating.

7. INDUSTRIAL

Costs and savings over 15 years

Figure 7.3: Costs and savings compared to 'doing nothing'



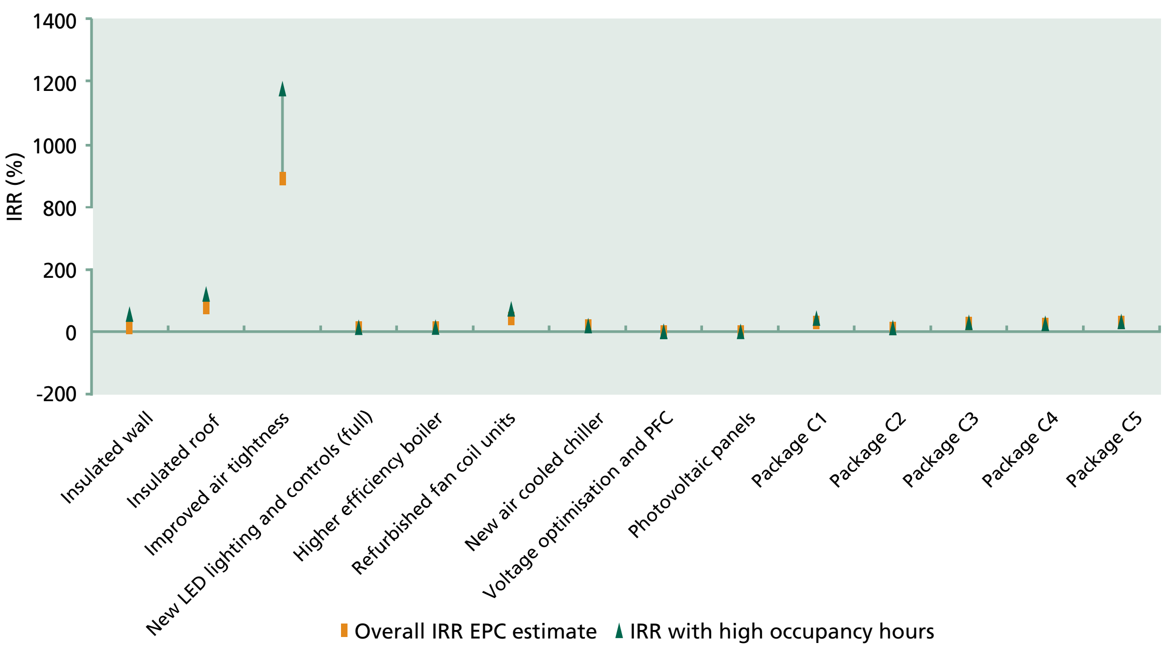
Key points

- Due to the poor performance of the base building insulation and systems, all of the improvement measures show a net saving over 15 years and the most significant benefits come from fabric improvements and lighting upgrades and from packages containing these measures.
- Because of the relatively small area of the office space, and the paucity of opportunities to improve the industrial space, the benefits from improving the office space are proportionately much smaller than those for the rest of the building, albeit still delivering a net saving.

7. INDUSTRIAL

IRR of measures

Figure 7.4: Internal Rate of Return compared to 'doing nothing'



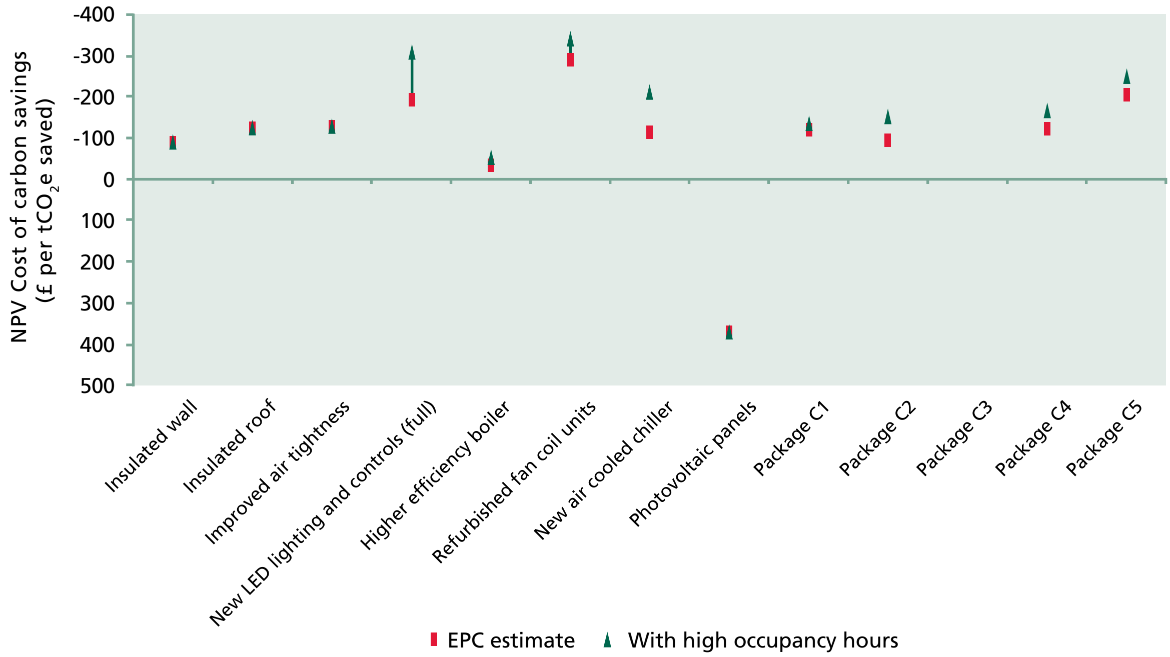
Key points

- All of the measures, with the exception of PV, show a positive IRR over 15 years, with roof insulation and air tightness showing very positive IRRs of over 50%. Packages of measures, especially C1 (sufficient to achieve an EPC of B), also show very positive IRRs.

7. INDUSTRIAL

Cost of carbon reduction

Figure 7.5: Cost of carbon reduction compared to 'doing nothing'



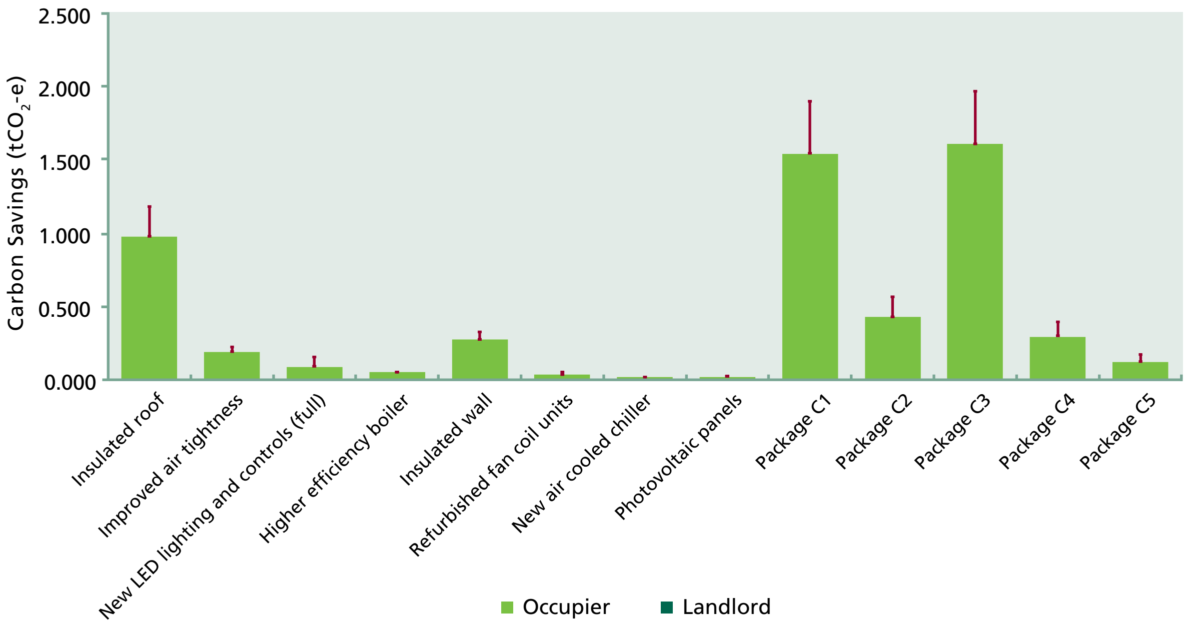
Key points

- All options, with the exception of PV, show a negative cost of carbon reduction, indicating they save both money and carbon over 15 years.

7. INDUSTRIAL

Total carbon saving

Figure 7.6: Total carbon saving compared to 'doing nothing'



Key points

- Carbon savings over 15 years are most significant for fabric improvements, such as roof and wall insulation and packages containing these measures.
- Lighting improvements are mainly to space that is heated only (i.e. in the industrial space) and, as a result, the carbon savings in electricity consumption is offset by increased heat demand.
- Packages C1 and C3 (involving fabric and lighting improvements) deliver savings of over 1.5 tonnes of CO_2e per m^2 over 15 years.

7. INDUSTRIAL

Carbon reduction in comparison to 2017 emissions

Figure 7.7: Reduction in carbon emissions (gas and electricity) compared to 2017

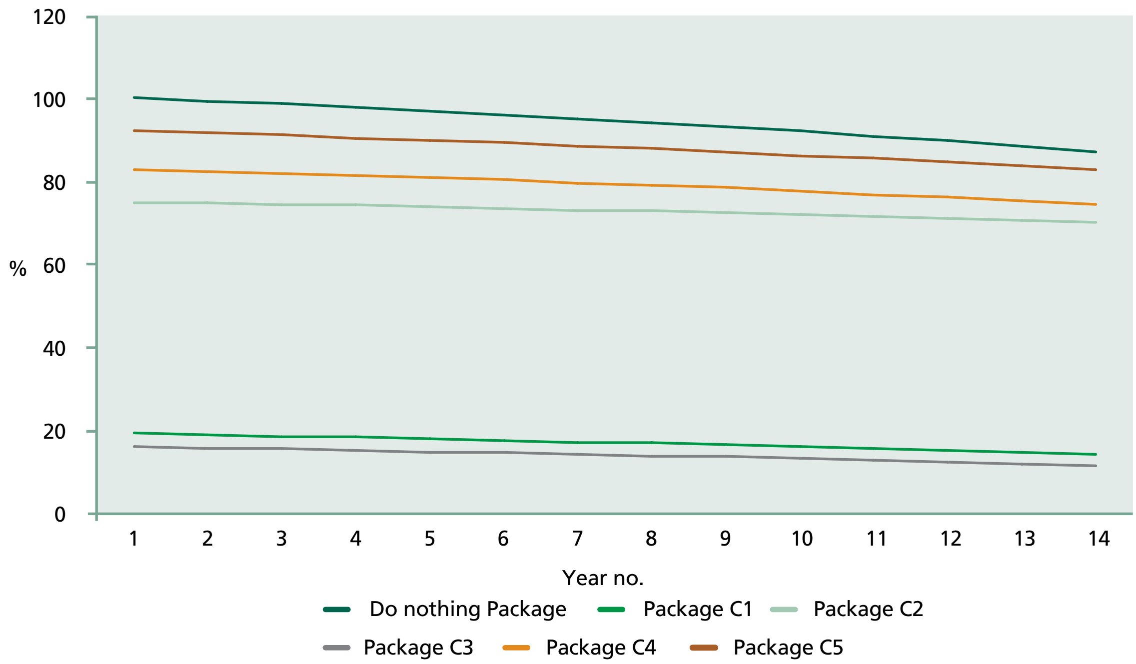
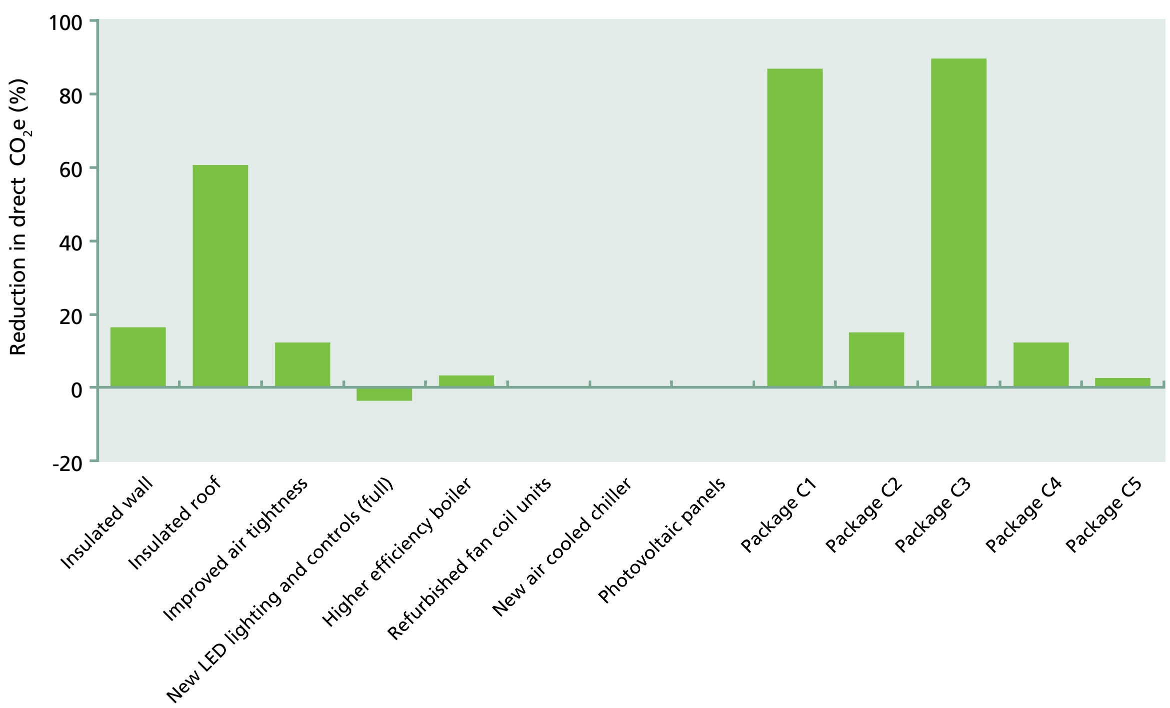


Figure 7.8: Reduction in direct emissions (gas only) compared to 2017



7. INDUSTRIAL

Key points

- The relatively small reduction in carbon emissions for the baseline building between 2017 and 2030 demonstrates the importance of heating (gas) as a source of emissions for this building. Packages of measures that address the thermal performance of the building (C1 and C3) demonstrate emission reductions of over 80% against the baseline building.
- Improvement packages that do not address the thermal inefficiency of the building (i.e. C2, C4 and C5) show some improvement over the baseline building – of up to c.25% in the case of C2 (a complete package of services upgrades to both office and warehouse space) – but do not approach the level of saving required by 2030 to be consistent with the trajectories set out to support the Climate Change Act emission reduction targets.
- Fabric improvements reduce direct emissions, with roof insulation alone resulting in savings of c.60%. Packages of measures can deliver savings of c.85-90% in comparison to the baseline building.

7.2 Summary of Industrial Building Findings

In contrast to the other buildings studied, the most effective means of improving the EPC rating and long-term carbon and cost performance of the industrial building are fabric upgrades. This is due to the poor standard of the baseline building (with uninsulated roof and walls) and also because, as a largely single storey building, it has a very large roof relative to its internal floor area.

Upgrades to lighting and to the servicing of the office area deliver net cost savings and good IRRs; however, their impact on the building's overall carbon performance is relatively small in comparison to roof and wall insulation.

Many industrial buildings will have better fabric performance standards than that assessed in this example. However, a review of roof insulation, airtightness measures and lighting performance are likely to identify the most significant financial and carbon saving opportunities.

8. TAKING ACTION

The sample of buildings covered in this study demonstrate that cost effective energy efficiency measures exist for a range of building types of different age and condition. The following steps are recommended to help landlords prioritise their portfolios and take the right steps to improve building performance:

- Determine corporate objectives relating to energy and carbon performance and the level of risk placed on the value of the portfolio;
- Identify priority buildings; these may possess several of the following characteristics:
  - Poor EPC rating;
  - No EPC, but will require one before 2023 as a result of a lease event;
  - Large size/asset value;
  - Competitive local market (otherwise comparable buildings with better ratings nearby);
  - Upcoming lease/sale events;
  - High maintenance costs (indicating that plant may be at the end of its economic life); and/or
  - Long lease term (thereby enabling an occupier to recoup a contribution to improving the building through their own energy saving initiatives).
- Review performance of priority buildings, including:
  - Review existing EPC rating and, if considered inadequate (e.g. frequent use of default assumptions for key items), commission a new assessment;
  - Review available data on actual energy consumption (even if only for communal areas), to identify opportunities for quick savings by controlling out of hours consumption (e.g. overnight and weekends) and through adjustment of run times and loading of key plant;
  - Use energy modelling, ideally including actual energy data, to identify opportunities to further improve energy and carbon efficiency through investment; and
  - Review the costs and impacts of different improvement options; costs provided in this report could be used as a guide, during initial scoping with a surveyors assessment of possible measures to develop project specific costs and delivery plans.
- Develop a costed improvement strategy for each priority building to include:
  - Target performance and rationale (risk of occupier loss, protection of asset value, need for essential lifecycle expenditure, compliance with corporate policy, etc.);
  - Improvement measures, to include both management[13] and asset investments;
  - Timescale for implementation, taking into account external factors (e.g. MEES regulations), planned lifecycle investment, likely timing of vacant possession, etc.; and
  - Key tasks and responsibilities for managing delivery.

Care should be used in applying the finding of this study to specific buildings as each building is different. In many cases, the specifics of design, construction, lease, etc., can have a major impact on both the costs and impacts of individual measures. For example, plant replacement costs can increase substantially where access is restricted or where the need for additional works comes to light. Within this study, allowances have been made for likely work in connection with replacement measures; for example, when replacing old boilers, allowance is made for some replacement of pipes and controls in the plant room. Each situation is different, however, and seemingly inconsequential factors can impact costs considerably.

[13] Management tools such as sub-metering have not investigated in this study, but they form an important component in achieving a good return on investment in services.

APPENDIX A. GLOSSARY OF REGULATIONS AND INCENTIVES

The following list of government regulations, market incentives and drivers is not exhaustive but provides further information, as referenced in section 2 of this report.

Legislation/scheme	Background & Requirements
The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007	All non-domestic and non-public buildings (with a few exceptions) require an Energy Performance Certificate (EPC) when they are constructed, sold or let. An EPC provides a rating of the theoretical energy performance of the building from A+ to G. The rating is intended to enable the purchaser or occupier to consider energy efficiency as part of their investment or business decision to buy or occupy the building. The energy rating is based on the thermal performance of the building fabric (insulating qualities, prevention of solar gain) and the expected energy consumption of the heating, lighting and air conditioning systems. The rating is not based on actual energy consumption (as is the case for Display Energy Certificates in public buildings) but on an estimate of energy consumption assuming standard occupancy patterns. This is known as the 'Asset Rating'. The EPC for England and Wales gives ratings from A+ to G, which are based on a CO_2 performance index (compared with a reference building) rather than absolute performance. The position in Scotland is different and compares buildings in terms of their absolute CO_2 emissions in $kgCO_2/m^2$.
Minimum Energy Efficiency Standards (MEES)	Following public consultation between July and September 2014, in February 2015, the Government released the MEES regulations which will apply to commercial and residential properties. From 1 April 2018, it is a legal requirement for landlords to grant new lease properties with a minimum EPC rating of E.
Climate Change Levy (CCL)	Climate Change Levy implemented by the government is a tax on electricity, gas and solid fuels. Levy rates must be paid if the business is in one of the following sectors: industrial, commercial, agricultural or public services. A reduction in the main rates of CCL is available if the business is energy intensive and the operator has entered into a climate change agreement (CCA) with the Environment Agency. Current (2017) rates for electricity are 0.00568 £ per kilowatt hour kWh and, for gas, 0.00198 £ per kWh. These are set to increase steadily annually at the start of each financial year. The Carbon Reduction Commitment (CRC) Energy Efficiency Scheme will be merging with CCL as of 2019 and CCL rates will be raised to compensate for this.
Part L	In accordance with reg. 26 of the UK Government building regulations, calculated CO_2 for the building (BER) must not exceed the targeted levels (TER). This regulation applies to the standards for the energy performance of both new and existing buildings. In existing buildings, where the improvement of an individual thermal element constitutes a major renovation or amounts to the renovation of more than 50% of the element's surface area, the renovation must be technically, functionally and economically feasible. Only existing buildings with a total useful floor area over $1000m^2$, proposing an extension, initial provision of any fixed building services or an increase to the installed capacity of any fixed building services, must comply with the requirements of Part L of Schedule 1.

APPENDIX A. GLOSSARY OF REGULATIONS AND INCENTIVES

Legislation/scheme	Background & Requirements
Science Based Targets	This incentive is a collaboration project between CDP, World Resources Institute (WRI), the WWF and the United Nations Global Compact. Companies wishing to set science based targets should submit a commitment letter, develop a target within 24 months, validate and announce the target. SBT initiatives will support the organisation to achieve these targets.
Global Real Estate Sustainability Benchmark (GRESB)	An investor-driven organisation, committed to assessing the environmental, social and governance issues of participating businesses. GRESB focuses on estates and funds as a whole rather than at the individual asset level. Businesses can apply for membership at a fee of EUR 5,300 – EUR 10,600, depending on assets under management and the type of data access required. Performance indicators are used against collected portfolio level data on energy and water consumption, GHG emissions and waste. Assessment of this performance data is a three part process: report absolute data, benchmark data coverage per property type and benchmark like-for-like change per property type.
Enhanced Capital Allowance	Government Enhanced Capital Allowances enable businesses paying income or corporation tax to claim 100% first year capital allowance on a product if it is listed on the Energy Technology List (ETL).
Feed-in-Tariffs (FiTs)	This government scheme, delivered by Ofgem, provides a generation tariff for each unit (kWh) of electricity generated. Rates are dependent on the size and age of the system and efficiency of the technology installed. Export tariffs are also available with this scheme. Tariffs are also considerably higher, the greater the energy efficiency of the technology type used. To get FiTs at the standard rate for solar PV, the property must have an Energy Performance Certificate of band D or better. EPC banded properties of E, F or G will need to carry out energy efficiency improvements before they become eligible.
Non-Domestic Renewable Heat Incentive	This government scheme, delivered by Ofgem, provides quarterly payments over 20 years, based on the amount of heat generated for eligible installations. Eligible technologies include biomass, ground source heat pumps, water source heat pumps, geothermal and solar thermal. Air source heat pumps are also certified, providing they have not been designed for the functionality of cooling.
BREEAM	The Building Research Establishment's Environmental Assessment Method provides environmental certification at a rating dependent on the building's sustainability credentials. A minimum standard for achieving Excellent rating is an Energy Performance Ratio of 0.375. Another minimum standard for Very Good & Excellent rating is that 90% of major energy consuming systems must be sub-metered. BREEAM is not only applicable to new buildings but also refurbishment and in-use developments, recognising improvements in energy performance above national building regulations and encouraging steps taken to reduce energy demand through building design and systems specification.

APPENDIX B. METHOD

B.1 Overview

The basis of the research was to assess the costs associated with making energy efficiency improvements to a selection of existing building architypes. Measures included those that might be undertaken as part of a market standard refurbishment and also the use of more energy or carbon efficient technologies or systems. To demonstrate which of these improvements were most cost effective, capital cost of the upgrade and its longevity was quantified and set against its estimated impact on energy use and the associated costs and carbon emissions.

Measure and package selection

For each building, a series of refurbishment measures were selected, reflecting the key contributors to regulated energy and carbon emissions, and including those items identified in Building Regulations Part L2b, Table 6 (see Table 2.1 in this report). Table 6 is an important reference point as, under MEES regulations, landlords will need to consider the listed measures when evaluating which might be suitable and cost effective to apply to improve the rating of their buildings.

As the scope of this study covers refurbishment, but not full redevelopment, some smaller or larger improvement measures have not been included. For example, insulation of plant room pipework or valves or, at the other extreme, recladding or changing façade designs. Previous analysis of fabric upgrades (and of window replacements in this study) has suggested that these are prohibitively expensive unless they form part of a more thorough redevelopment to reposition the asset in its market.

Packages of measures were selected based on a series of factors including:

- Measures shown to be cost effective when applied in isolation;
- Measures that might be undertaken together as part of replacement of measures with similar longevity that, if installed together in a new building, might be expected to be replaced at a similar time if the building were to become vacant;
- Measures that might be undertaken as part of landlord works to central plant and communal areas or as part of an occupier's fit-out/refit of its space (e.g. lighting and terminal units); and
- Inclusion of at least one option that replaces gas-based heating with electric heating via an ASHP.

Based on the above considerations, up to seven different packages of measures were developed for each building, covering combined works and those specific to landlord- or occupier-influenced areas.

Capital cost estimation and assumptions

Costs were estimated for each building type modelled and represent the total cost to a client of construction work. This includes materials, labour, builder's work in connection, preliminaries, overheads, contingencies and profit. Design fees have not been included, based on the assumption that any increase in design fees associated with the upgrade will be marginal. Other excluded costs include Value Added Tax, Building Control fees, survey fees, legal fees and finance costs. All costs are current at Q2 2017 price levels.

It has been assumed that all improvements modelled can be carried out within the existing buildings without structural alterations or reworking floor layouts and positions of ducts, etc., and the capital costs reflect this.

APPENDIX B. METHOD

Modelling CO_2 emissions and energy consumption

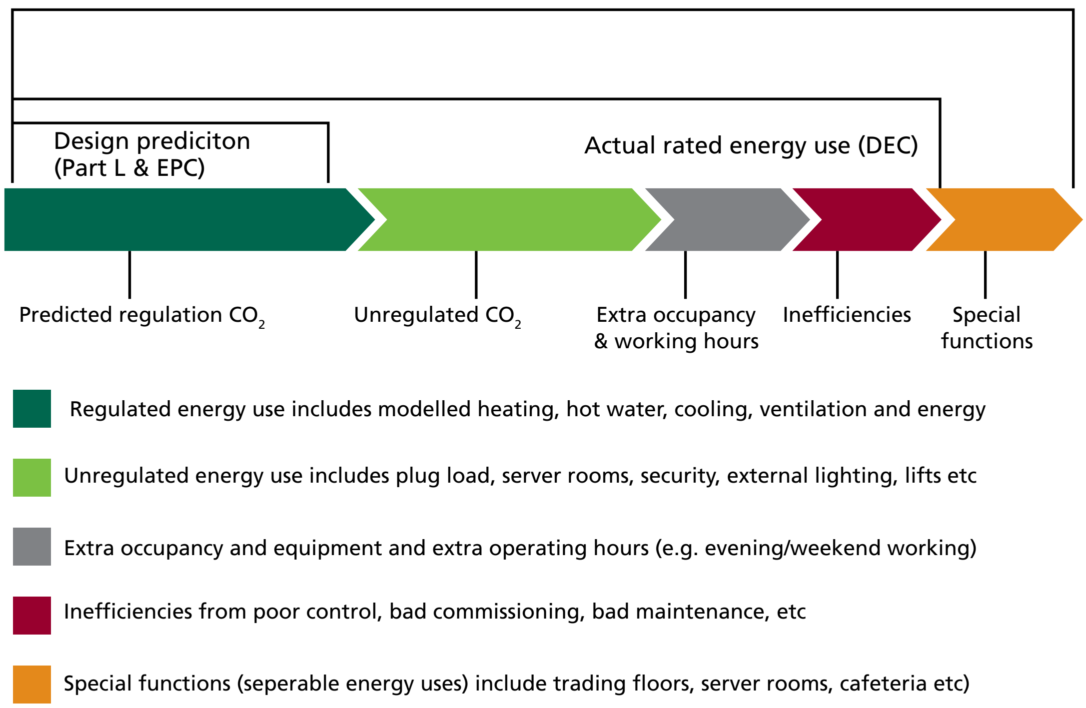
Assessing energy consumption and CO_2 emissions was undertaken using SBEM (Simplified Building Energy Model) software (version v5.3.a). SBEM was developed by the Department for Communities and Local Government for the purpose of demonstrating compliance with Part L of the Building Regulations and to produce EPC ratings for non-domestic buildings.

To minimise the number of assumptions being made, standardised data from the National Calculation Method (NCM) database, which is used for all Part L calculations, was used in the analysis.

Adjusting for indication of 'actual' consumption

Part L and EPCs only regulate and predict a proportion of CO_2 emissions in a building as shown in Figure 3.3. Specifically, only heating, cooling, hot water, ventilation and lighting energy consumption is accounted for and assumes standard working hours and occupancy. The EPC modelling process did not include, therefore, any allowance for occupants' equipment or appliances or account for extended working hours for example.

Figure B.1: Building energy consumption measured by Part L, EPCs and DECs[14]



To help provide an indication of the impacts of efficiency measures on actual energy consumption, the analysis of the EPC performance (using SBEM) was adjusted to include both additional hours of occupation and unregulated energy. No allowance was made to account for inefficiencies in the management of the buildings or the presence of special functions that might impact both regulated and unregulated energy consumption in the building.

[14] Carbon Trust (2011), Closing The Gap, available from the Carbon Trust website (ref CTG047) www.carbontrust.co.uk

APPENDIX B. METHOD

The impact of increasing hours of occupation was estimated by reference to adjustment factors in CIBSE Guide TM46. These factors were used to separately adjust heating and electrical energy demand between the standard hours assumed in the National Calculation Model used for Building Regulations and a higher assumed maximum duration of occupation. Table A.2 shows the assumed base hours, maximum occupancy hours and the assumed higher occupancy scenario used in the study, together with the associated implications for both gas and electrical energy consumption.

Table B.1: Impact of additional hours of occupation on energy consumption

Building type	Reference hours (as assumed in SBEM)	Maximum occupancy hours (as specified in CIBSE TM46)	Higher occupancy hours scenario	Impact on gas use of higher occupancy	Impact on electricity use of higher occupancy
Offices	2040	8760	4472	+16%	+39%
Retail warehouse	2448	4284	4284	+15%	+32%
Industrial unit	2040	4284	4284	+20%	+45%

Unregulated energy consumption is added to each model, based on separate data on average levels of unregulated gas and electricity consumption in each building type from buildings covered by the Building Energy Efficiency Survey.

B.2 Analysis

Seven-year cost effectiveness test

Compliance of different individual measures with the seven-year cost effectiveness test was determined through comparison of costs and savings over the seven year period as follows:

- Implementation costs:
  - Multiplication of capital cost by interest rate factor (current 0.144 where the Bank of England's Base Interest Rate is 0.25%) and then by seven years;
- Efficiency savings:
  - Change in annual gas and electricity costs multiplied by seven years.

Whilst the Bank of England's interest rate is included in the analysis, no discounting of future savings is included and it is assumed that unit charges for gas and electricity remain constant.

Lifecycle analysis

In addition to the seven year test, a series of further analyses were undertaken. These further studies used published projections[15] for the future unit cost and carbon intensity of energy together with information on the longevity of improvement measures based on RICS and CIBSE guidance documents.

Lifecycle analyses were undertaken on individual measures and packages and also included comparison of the relative costs and savings of one option in comparison with an alternate, typically less efficient 'standard practice' option.

[15] BEIS, 2016. Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions. Interdepartmental Analysts Group.

APPENDIX B. METHOD

Lifecycle analyses included the following assessments:

- Net present savings over 15 years at the public sector discount rate of 3.5%;
- Internal Rate of Return over 15 years;
- Total carbon savings over 15 years;
- Cost of carbon savings, based on the quantity of CO_2e saved over 15 years divided by the net cost (i.e. capital costs and operational savings);
- Reduction in carbon emissions, relative to the baseline building in 2017, between 2017 and 2030; and
- Reduction in direct carbon emissions, compared to the baseline building in 2017.

The core lifecycle analysis was undertaken using results from EPC modelling but, for each scenario, a second analysis considers the results for a higher level of occupancy, including unregulated energy. This analysis provides an indication of the sensitivity of the results to variations in use. In practice, the variation in performance may be wider than that estimated here as this analysis excludes consideration of inefficient management of the building or the presence of 'special features' that impact overall energy consumption.

APPENDIX C. KEY MODELLING PARAMETERS

The SBEM modelling software requires a range of physical building characteristics to be defined as model inputs in order to construct the base building models. Standard assumptions are made by the software in relation to building operation. The approach followed was to determine inputs that would best represent the building types under consideration. The key parameters are listed in Table C.1.

The floor area and geometry for each office is consistent with the original study; however, the retail and industrial buildings have been amended. The buildings are now over 5,000m², to reflect mid-size properties in both sectors.

Table C.1: Key modelling parameters

Input Variable	Base Building Modelling Parameters		
	Office	**Retail**	**Industrial/warehouse**
Building Geometry			
Gross Floor Area	5,400m² (6 storey)	Sales area: 4500m² Office: 600m² (two storey) Warehouse: 500m²	Main area: 4500m² Office: 600m² (two storey)
Floor plate dimensions	Deep plan: 30m x 30m Narrow plan: 60m x 15m	Sales area: 75m x 60m Office: 20m x 15m Warehouse: 25m x 20m	Main area: 75m x 60m Office: 20m x 15m
Storey height	3.7m	4m	4m
Glazing %	50% 80%	Office only	Office only
Glazing specification Office One	Double Single	Double	Single
Location	South East Business Park	Retail Park	Industrial Park
Building Fabric and Operation			
Age			
Office One	Pre 1940	Pre 1995	Pre 1995
Office Two	Pre 1995		
Office Three	2002		
Office Four	2006		
Building Services Strategy			
Heating system	Gas	Gas	Gas
Natural ventilation	Office One only	No	Natural ventilation
Air conditioning	Offices Two, Three and Four - Centralised system and fan coils	Centralised system and fan coils	None
Lighting			
Office One & Two	T8	T8	T8
Office Three & Four	T8		
Hot water	Gas	Gas	Gas
Renewable energy	None	None	None

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