Research Programme

Costing Energy Efficiency Improvements in Existing Commercial Buildings

SEPTEMBER 2017

SUMMARY 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

Summary report

IPF Research Programme 2015–2018

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Research Team

Adam Mactavish, *Currie & Brown Limited*
Azita Dezfouli, *Currie & Brown Limited*

Project Steering Group

Chris Urwin, *Aviva Investors*
Matthew Bennett, *Wells Fargo*
Jay Cable, *Picton*
Pam Craddock, *IPF*

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1. INTRODUCTION

Since the publication of the 2012 report on the costs of making energy efficiency improvements to 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, which comes into force in April 2018. Other changes include amendments to Building Regulations, revised or new incentives for generating renewable electricity and heat and the increasing use of light-emitting diodes (LEDs), a technology that was just emerging for mainstream lighting in 2012.

As well as the implementation of regulations, other regulatory levies and incentive mechanisms have evolved to encourage the adoption of energy efficient and low carbon technologies.

These current levies and incentives include:

- Climate Change Levy (CCL) – a tax on electricity, gas and solid fuels, set to increase from 2019 to compensate for the discontinued CRC (carbon reduction commitment) energy efficiency scheme;
- Feed-in tariff for generation of renewable electricity (FiT) – a generation tariff for each unit (kWh) of electricity generated;
- Renewable heat incentive (RHI) – an incentive for the generation of heat through renewable technologies; and
- Enhanced capital allowances (ECA) – Government Enhanced Capital Allowances that enable businesses paying income or corporation tax to claim 100% first year capital allowance for products on the Energy Technology List (ETL) (https://etl.beis.gov.uk/).

These changes, together with the importance of providing current information to the industry, have prompted the current research. In addition to updating previous analysis, this report provides new information, including:

- The absolute costs of implementing different options, as well as the variation between the costs of more or less energy efficient options, as the introduction of MEES regulations may oblige landlords 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 which would be expected from the calculations used to produce an Energy Performance Certificate (EPC);
- The distribution of costs and savings between landlord- and occupier-controlled areas; and
- The implications for decision-making of projected changes in the carbon emissions and cost of each unit of supplied gas or electricity.

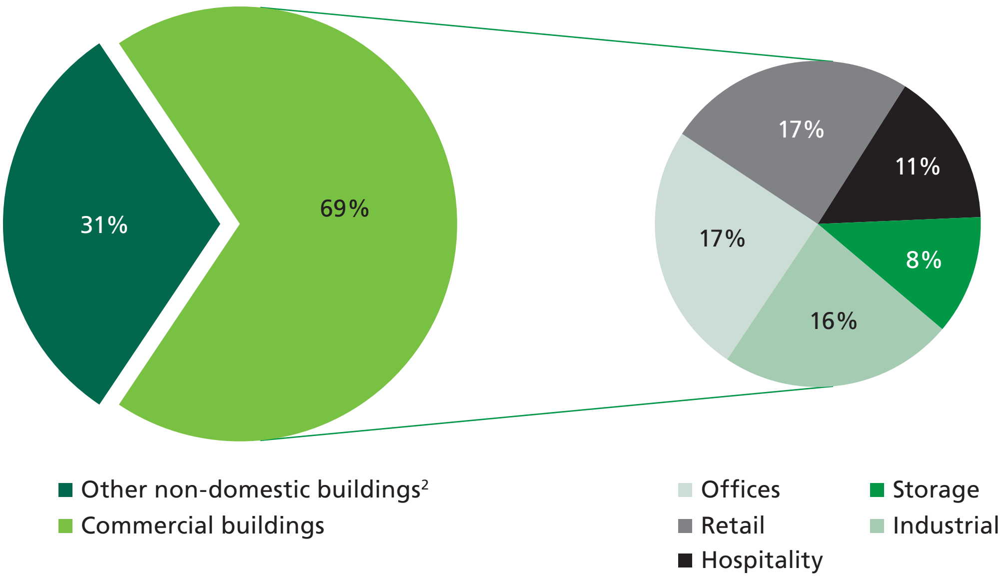
[1] Through the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015 and the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016.

2. ENERGY, CARBON AND COMMERCIAL BUILDINGS

2.1 Energy

Commercial buildings are responsible for approximately 70% of the energy used by non-domestic buildings (see Figure 2.1) . In offices and retail buildings, energy use is dominated by electricity consumption whereas, for other building types, the balance is more even or there is greater use of other energy sources – primarily gas for heating.

Figure 2.1: Energy consumption of non-domestic buildings



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

There is substantial variation in both the scale and composition of energy use between and within each building type. The BEIS survey also reports that heating and lighting for all building types are prime sources of energy consumption, with cooling, ventilation and ICT (information communications technology) also being important in offices, whilst cold storage facilities are important in overall warehouse and retail energy use. The variation of energy use is substantial within each building type too; in offices, for example, many air-conditioned buildings use more energy for cooling than heating.

2.2 Carbon

Commercial buildings are responsible for around 8% of UK greenhouse gas emissions[3], almost entirely due to energy consumption.

[2] Other non-domestic buildings include hospitals, schools, universities and other public buildings.
[3] Committee on Climate Change, 2016. Meeting Carbon Budgets: 2016 Progress Report to Parliament. www.theccc.org.uk

2. ENERGY, CARBON AND COMMERCIAL BUILDINGS

The carbon impact of electricity consumption has changed markedly in recent years as a result of decarbonisation. The CO_2e emissions linked to the generation of each kWh of grid electricity declined by around 45% between 2010 and 2017. Consequently, the marginal emission factor (i.e. the factor used to calculate carbon savings from reducing grid energy consumption) has reduced by 16%[4]. This marginal emission factor is projected to reduce further in the coming decades, to below 0.13 $kgCO_2e$ per kWh in 2030 – a 70% fall from 2010 levels.

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[4], relies on the UK becoming more energy efficient. Secondly, the investment needed to decarbonise the grid is likely to result in the cost of supplied electricity increasing in the future. Hence, while electricity use may have lower carbon emissions, it is likely to become around 55% more expensive than current production costs (see Appendix A).

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

3. APPROACH AND METHODOLOGY

3.1 Selection of generic building types

The types of commercial building analysed are largely consistent with previous studies but with certain revisions to address the new Building Regulations. Table 3.1 gives a notional presentation of the buildings assessed in this research.

The key data tables and analyses are detailed in the full report and may be used to evaluate results for a specific building and/or technology option. However, these are indicative benchmarks and, therefore, require careful consideration before being applied to a specific building.

Table 3.1: Building models

Office One

Reflects London Mid Town and West End offices that are predominantly period, dating from pre-1940. Heating system only.	
Services	Heating only
Plan depth	Narrow
Age	Pre 1940s
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 Three but compliant with 2006 Part L Building Regulations.	
Services	Air-conditioned
Plan depth	Deep
Age	Post 2006
Glazing % and type	80% double

3. APPROACH AND METHODOLOGY

Table 3.1: Building models (cont'd.)

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 rooflights. Offices included. Compliant with 1990 Part L Building Regulations.	
Services	Heating only
Plan depth	Deep
Age	Pre 1995
Glazing % and type	10% single

3.2 Energy modelling

Using SBEM (Simplified Building Energy Model) software (version v5.3a) to demonstrate the existing EPC rating, a series of refurbishment measures and packages were selected for each building, based on:

- MEES legislation of seven-year cost effectiveness;
- Longevity of the measures; and
- Whether it might be taken as part of landlord works to central plant and communal areas or as part of an occupier's fit-out/refit of their space (e.g. lighting and terminal units).

To provide an indication of the impacts of efficiency measures on actual energy consumption, the analysis of the EPC performance was adjusted to include both additional hours of occupation and unregulated energy. For this study, no allowance has been 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.

3. APPROACH AND METHODOLOGY

3.3 Lifecycle modelling

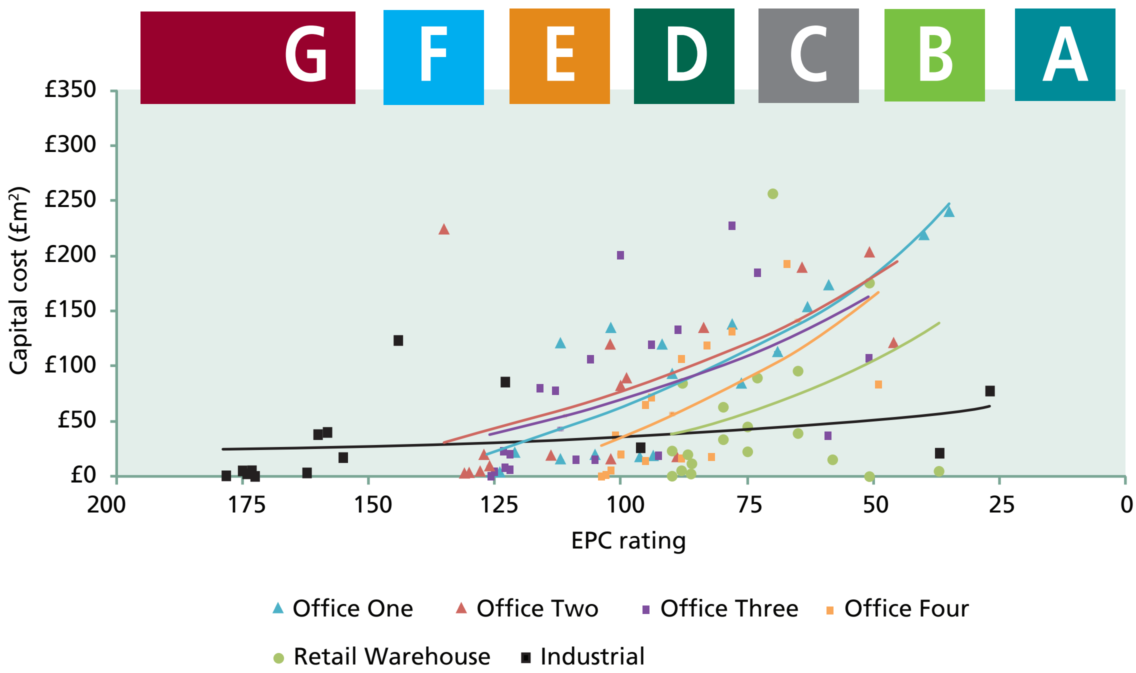
To demonstrate which of these improvements was the most cost effective, capital costs of the upgrades and their longevity were quantified and weighed against their estimated impact on energy use and the associated costs and carbon emissions. Future carbon emissions were estimated, based on UK Government projections of the future carbon intensity of energy supply from gas and electricity.

The core lifecycle analysis was undertaken, using results from EPC modelling, but, for each scenario, a second analysis considered the results for a higher level of occupancy and including the use of unregulated energy.

4. FINDINGS

Summary findings for each building type are shown in Figure 4.1. Although the study assessed varying building types with different ages, condition and levels of servicing, there is a level of consistency in the cost trend lines for improving the EPC rating of each asset.

Figure 4.1: Cost of improving EPC ratings of commercial building types



The trajectory and positioning of the cost curves for each building are broadly similar. However, after lighting, which is an important efficiency measure for all buildings, the measures that are most influential in improving asset ratings vary between buildings. For example, for Office One (naturally ventilated), the major savings are achieved through lighting and the use of efficient boilers or heat pumps, whereas, for Office Four (a post 2010 air-conditioned building), savings are linked to more efficient fan coil units (FCU) as well as lighting.

4.1 Offices

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

4. FINDINGS

4.1.1 Summary of Office findings

a. 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, replacement of boilers and other measures, such as the installation of variable speed pumps.

b. Cost effective energy savings

- From a cost effectiveness and energy use perspective, lighting improvements deliver the most significant savings for a majority of 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) is the most important measure.
- For the majority of 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 of glazing systems; these are, typically, far less cost effective and, in more highly glazed AC buildings, may have a negative effect on energy use, cost and emissions.
- For the naturally ventilated building, the installation of an ASHP (air source heat pump) is expensive relative to a new gas boiler, although payments from the RHI result in a similar net cost over 15 years, albeit at a lower IRR. However, carbon savings derived over 15 years from installing an ASHP are nearly double that of even a highly efficient gas boiler.
- The costs of fully replacing the lighting and control system are not recovered purely through energy savings, although a 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 technologies that have developed most substantially in the last decade.

c. Carbon savings

- As a result of decarbonisation, even under a 'do nothing' scenario, carbon emissions reduce in each building (due to Government's decarbonisation programme). However, substantial additional savings are available through use of existing technology, such that, by 2030, emissions could be close to 80% lower than those in the 2017 baseline buildings.
- Measures with the most substantial impact on direct emissions are fabric improvements (e.g. new glazing), more efficient boilers and, most significantly, the adoption of electric heating (ASHPs). The installation of efficient lighting tends to increase direct emissions in all buildings because they emit less heat 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). Nevertheless, this should not discourage the adoption of energy efficient lighting, which is both cost and carbon efficient. However, it does demonstrate that, at some stage, landlords will need to implement further measures to 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.

4. FINDINGS

- Carbon savings from lighting improvements are greater for AC buildings (or naturally ventilated buildings using heat pumps for heating) as 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.

4.2 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, which must then be reduced by additional energy use for cooling. Use of efficient lighting systems can therefore make a major energy efficiency contribution 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 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. It can often be the case that the landlord becomes responsible for the 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 in order to make the appropriate decisions about the preparation and marketing of the space.

4.2.1 Summary of Retail Warehouse findings

It is possible to achieve an EPC of B at a cost of 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 from £100 to over £150 m^2 over 15 years.

Even though the base building had 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 £20-35 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 carbon saving opportunities for this building are from roof insulation and the installation of an ASHP for heating and cooling, however the financial returns from these options are not attractive.

4.3 Industrial

The manufacturing or trade processes carried out within industrial properties often account for the vast majority of energy consumed by the building. In general, for industrial space that is flexible enough to accommodate a variety of industrial processes, 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 constructed as a shell, for the manufacturer to wholly fit-out, or be bespoke built by the manufacturer for owner-occupation or sold on a sale and leaseback arrangement. Therefore, for general light industrial buildings, the main opportunities for landlords lie in improving the thermal performance, lighting efficiency and heating systems. Given that these 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).

4. FINDINGS

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

4.3.1 Summary of Industrial findings

In contrast to the other buildings evaluated, 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 primarily due to the poor standard of the baseline building (with uninsulated roof and walls) but also because, as a largely single story 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, the impact of these improvements on the building's overall carbon performance is relatively small in comparison with roof and wall insulation.

Whilst many industrial buildings will have better fabric performance standards than those assessed in this study, a review of roof insulation, airtightness measures and lighting performance are highly beneficial in identifying the most significant financial and carbon saving opportunities.

5. 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 ages and condition. The following steps are recommended to help landlords prioritise their portfolios and take the appropriate steps to improve building performance:

- Determine corporate objectives relating to energy and carbon performance and the level of risk it places on the value of the portfolio;
- Identify priority buildings; these may have several of the following characteristics:
  - Poor EPC rating;
  - No EPC, but where one will be required 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 savings);
- Review performance of priority buildings, including:
  - Review existing EPC rating and, if considered inadequate (e.g. frequent use of default assumptions for key plant 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 may be used as a guide) during initial scoping with an 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[5] 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.

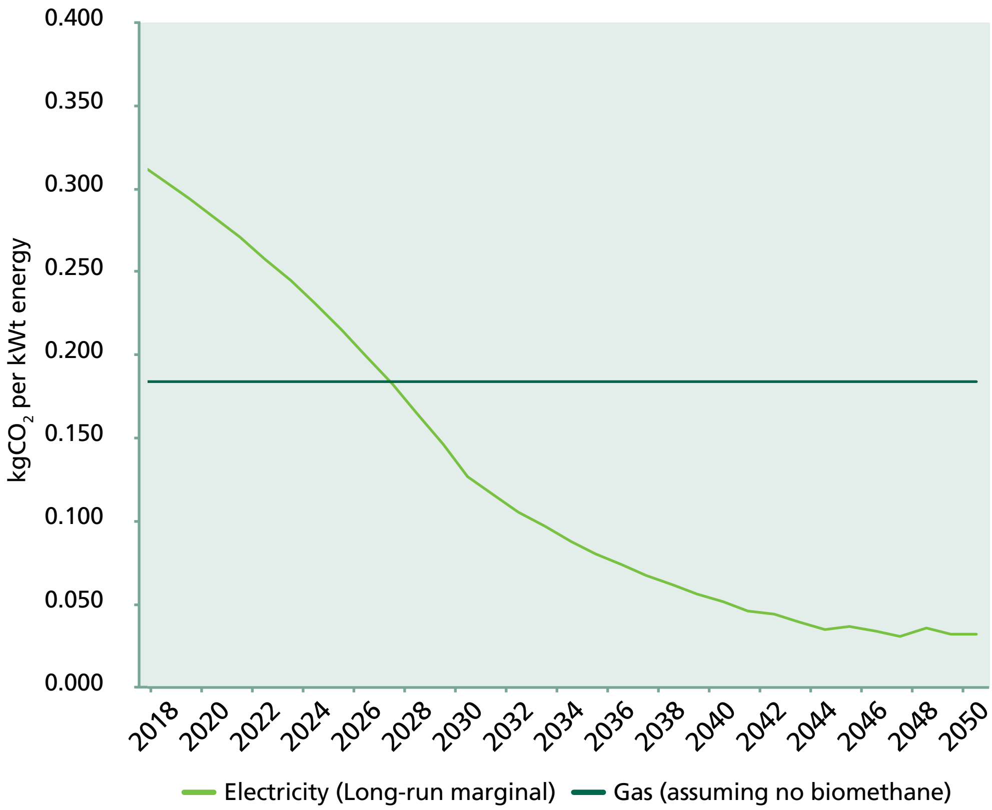
In applying the finding of this study to individual buildings, care must be taken, as the specifics of design, construction, lease, etc., may have a major impact on both the costs and impacts of individual measures. For example, plant replacement costs can increase substantially where access is restricted or where the need for additional works becomes known. 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.

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

APPENDIX A - 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, as a result of 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[6]. This marginal emission factor is projected to reduce further in the coming decades (see Figure A.1), to below 0.13 kgCO_2e per kWh in 2030 – a 70% fall on 2010 levels.

Figure A.1: Projected marginal carbon intensity of energy

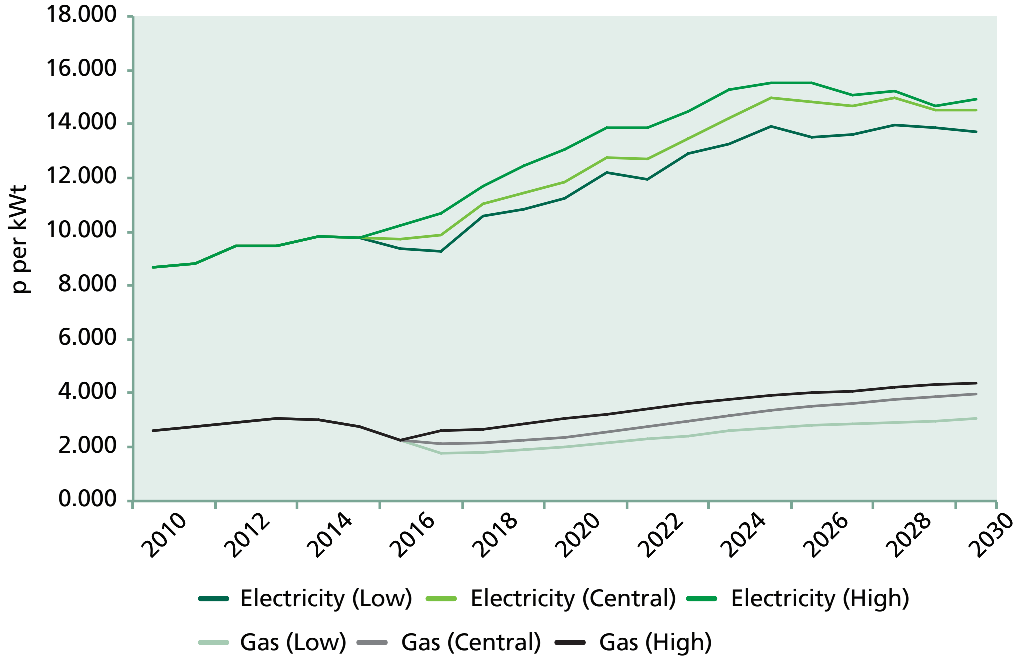


The anticipated further decarbonisation of the electricity grid means that emissions from commercial buildings should reduce in the future. However, this is not cause for complacency for two important reasons. Firstly, the ability to decarbonise in line with the Government's projection relies on the 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 A.2) 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.

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

APPENDIX A - THE IMPACT OF GRID DECARBONISATION

Figure A.2: Projected costs of commercial energy supply



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 now been established up 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 A.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 4th budget will not be achieved.

Table A.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

APPENDIX A - THE IMPACT OF GRID DECARBONISATION

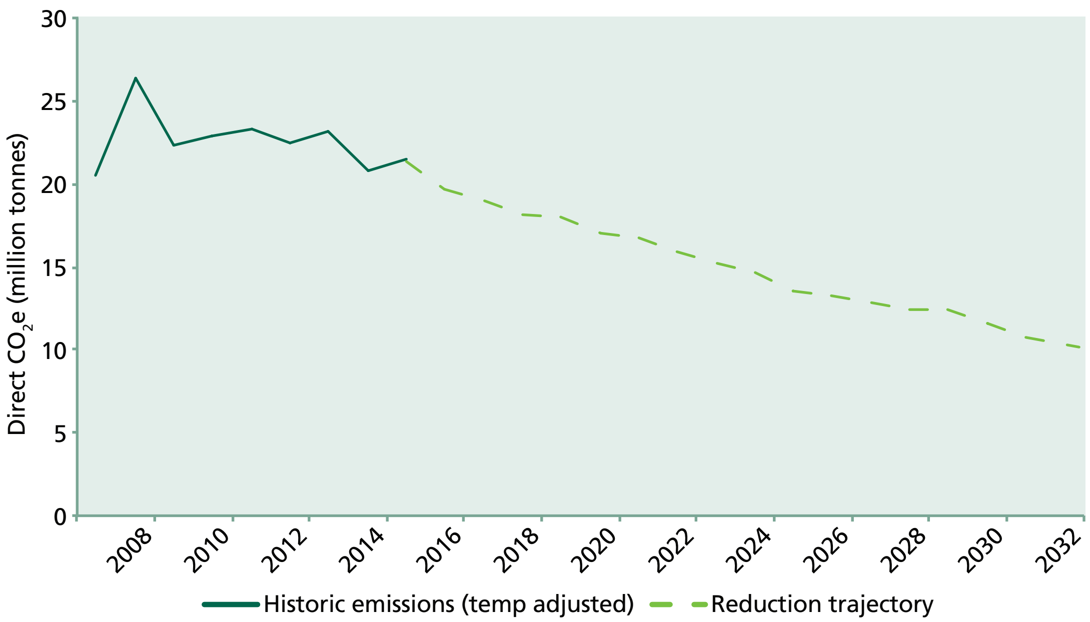
The most recent report tracking UK performance against current and future carbon budgets raises major concerns about progress in the non-residential buildings sector.

"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 onsite 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 A.3), this targets a 29% reduction on 2007 levels by 2027 and proposes that direct emissions are 50% below 2007 levels by 2032.

Figure A.3: Direct carbon emission reduction trajectory for non-residential buildings



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 much of the reductions in direct carbon emissions will be achieved through the adoption of electric heating options (e.g. heat pumps) and so even achieving a slight reduction as a sector will be difficult without substantial efficiencies to offset the additional heating load.

NOTES

Research

Investment Property Forum
New Broad Street House
35 New Broad Street
London EC2M 1NH

Telephone: 020 7194 7920
Fax: 020 7194 7921
Email: ipfoffice@ipf.org.uk
Web: www.ipf.org.uk

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