2. Reducing energy demand from buildings

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This chapter sets out the trends and drivers of energy demand in buildings. It also sets out the policy for buildings in the UK and recommendations for government policy and CREDS work.

Energy demand trends and drivers

Buildings are central to our lives because they provide us with shelter and comfort at home, enable us to carry out productive activities at work and to provide other services, such as warehousing. Heating, cooling, lighting and appliances dominate the use of energy in both domestic and non-domestic (commercial and public) buildings.

There are 27 million dwellings and 2 million non-domestic (industrial, commercial and public) buildings in the UK. Together they are responsible for around 698 TWh or 43% of total delivered UK energy of 1642 TWh[1] (BEIS, 2018a), and 29% of UK CO_2 emissions (Committee on Climate Change, 2018).

Energy demand trends for buildings come with several caveats. The weather, in particular external temperature, influences demand, but adjustments to official numbers to take account of this can be hard to interpret. There are also gaps in the official record, and variations in how buildings are categorised, particularly for non-domestic buildings, which can appear as industry, service or 'other'. Also, some energy vectors like electricity are not disaggregated by sector. Disaggregating industrial process use from building use is challenging in some non-domestic sectors. Most importantly drivers of demand such as floor area and heating demand and efficiency have not been consistently monitored and are instead modelled with many assumptions.

However, with these caveats, a number of trends in delivered energy can be identified for both domestic and non-domestic buildings.

1 Original data units (mtoe) have been converted to TWh.

Trends and drivers in domestic buildings

Overall, non-temperature corrected domestic energy consumption was 466.4 TWh in 2017, 8.8% higher than in 1970. Demand reached a peak of 573.4 TWh in 2004 and has since fallen by around 19%. Natural gas and electricity dominate domestic energy consumption with 64% and 23% respectively, with the remainder coming from solid fuels, biomass, petroleum and external sources of heat.

Gas consumption rose by 280% from 1970, to a peak of 396.6 TWh in 2004 before falling by 25%. Gas is used for heating (76%), hot water (23%) and cooking (1%).

Electricity consumption rose by 60% from 1970, peaking at 125.6 TWh in 2005 and then reducing steadily by 12%. Electricity is used mainly for appliances (59%), heating (17%) and lighting (13%).

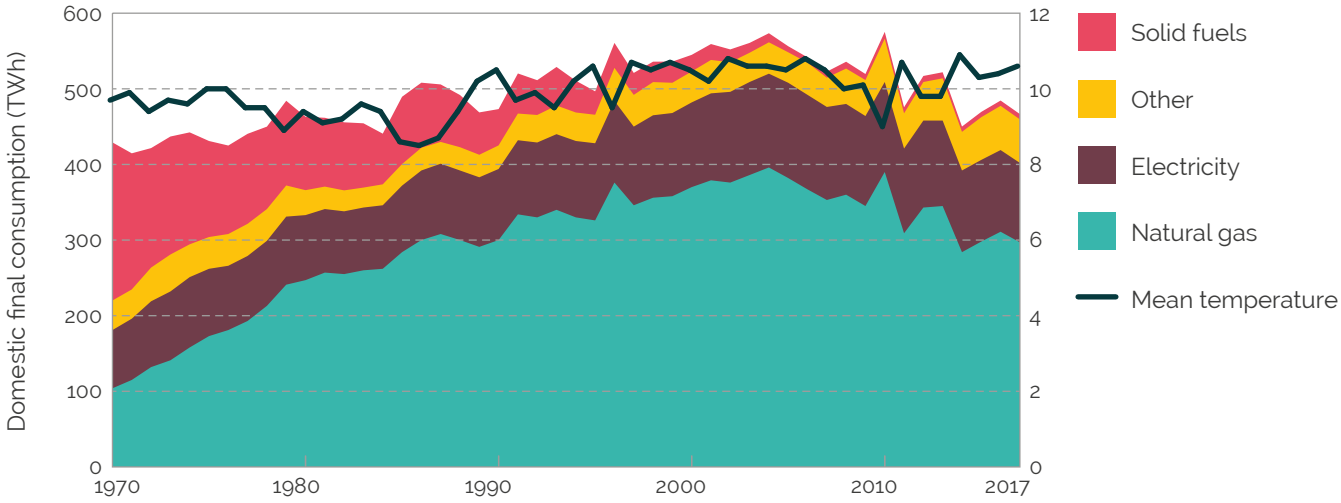

Figure 3: Final domestic energy consumption by fuel. Source: Energy Consumption in the UK, BEIS 2018.

The main factors increasing demand are the number of households (up by 50% from 18 million in 1970 to 28 million now), rising demand for heating and hot water (our homes are thought to be 4°C warmer now than in 1970 (DECC, 2013)), reductions in fuel prices (gas dropping in real terms by 41%, electricity by 32%, between 1983 and 2000) and increased electricity use from additional lights and appliances.

The rapid market penetration of energy efficiency measures has made a significant contribution to the fall in demand since 2003. Condensing boilers have become the dominant form of heating since they became mandatory in 2005, double glazing is in over 80% of homes now compared to 10% in 1983 and some degree of loft insulation is approaching market saturation (Committee on Climate Change, 2018). However significant potential remains: the Committee on Climate Change estimates that around 4 million cavity walls remain to be insulated (Committee on Climate Change, 2018).

For electricity the significant rise in the number of appliances in use has been offset by improvements in both operational and stand-by energy efficiency.

Between 2005 and 2012, gas prices more than doubled (+116%), and electricity costs increased by 42%. The Government considers that this, coupled with the economic downturn in 2008 and falling disposable income, is likely to have reduced energy demand over the period. However, there is no direct evidence for this.

There are some signs that the downward trend in domestic energy demand may be reversing, with 2016 and 2017 both showing temperature-corrected rises. However, is it too soon to predict any shifts in consumer behaviour.

Trends and drivers in non-domestic buildings

Overall service sector energy demand, of which around 93% comes from non-domestic buildings, was 238.4 TWh in 2017, which is 10% higher than 1970 (216.3 TWh) (BEIS, 2018a). The main energy consuming processes were space heating, lighting, catering, chilled storage and IT, detailed below.

- Commercial buildings dominate the sector with 67% of total demand. This has risen by 71% since 1970 (159.3 TWh in 2017 compared with 93 TWh in 1970). The main categories are industrial buildings, retail, leisure and hospitality.
- Public sector buildings accounted for 28% (65.1 TWh) of demand, which is 38% down on 1970 (101.2 TWh). The main categories are health, and central and local government.
- Agriculture accounted for 7% (17.4 TWh) which is 22% lower than in 1970 (22.0 TWh).

The upward trend in overall energy demand masks three sets of influences. Commercial sector activity has increased significantly as the UK has moved to a service-based economy. This has been largely offset by a 63% drop in energy intensity across the sector as a whole, although this intensity trend began to reverse in 2014 and has since risen by 11%. The improvements in efficiency in the commercial sector are thought to be due to higher densities of occupation, improved heating, cooling, ventilation and lighting efficiencies.

Policy principles and challenges

Policies for reducing energy demand in buildings have been well characterised in the academic literature, Government reports and by the work of Committee on Climate Change, most recently on the domestic sector (Committee on Climate Change, 2019). The main policy approaches are set out below.

1. Reducing demand and avoiding waste, e.g. heating fewer rooms and turning off lights and appliances. This is referred to as behaviour change and is a complex socio-technical phenomena involving interaction with control systems and new emerging uses of energy, sometimes stimulated by efficient technologies or building design.
2. Efficient conversion of delivered energy to useful energy by using more efficient heating systems, lighting and appliances.

3. Avoiding heat loss or heat gain by increasing fabric insulation, controlling ventilation and solar gains and integrating measures so that they work effectively together.
4. Integrating energy generation into buildings, for example solar thermal, passive heating via glazing, solar photovoltaics, or heat pumps. Although generation is not strictly demand reduction, it is hard to disaggregate unless it is separately metered and reported.

Buildings present many of the same barriers to change seen in other sectors. However, buildings, by nature and use, are highly diverse, which can make upgrading existing buildings difficult. As a result, policy has tended to focus on new buildings, and easier-to-install, more cost-effective interventions on existing buildings, such as like-for-like more efficient boiler replacements.

A wide variety of policy measures has been employed to do this: standards for building fabric and services e.g. Part L of the 2010 Building Regulations in England; performance standards for other technology used in the building (e.g. lights and appliances); and financial incentives, energy management standards and training, and feed-in tariffs or tax breaks to accelerate the market deployment of efficient and renewable generation technologies.

These policies have succeeded in reducing, or at least stabilising emissions. However, with 'low- hanging fruit' such as condensing boilers reaching market saturation, policy now needs to address the more difficult 'high hanging fruit' (also known as 'coconuts') such as heat pumps and solid wall insulation. A number of policy approaches can be used to accelerate the deployment of these technologies where the barriers to deployment are lower, for example installing heat pumps off the main gas grid (Cohen & Bordass, 2015).

However new buildings are a very small proportion of the stock: around 0.7% pa of the total UK commercial floor area (Property Industry Alliance, 2017) and 0.92%pa of dwellings in England (MHCLG, 2019). Sixty-five per cent of the existing UK non-domestic stock was built before 1991 and 24% before 1940 (BEIS, 2016). As a result, policy to deliver in the short- to medium-term such as the 5th Carbon Budget, needs to focus on existing buildings. However, in doing this policymakers face three significant challenges.

- The actual energy performance of a building can be twice as bad as predicted at the design stage (Cohen & Bordass, 2015). This performance gap is caused by a combination of poor modelling, deviations between design and build, and occupant behaviour (Carbon Trust, 2011). It is a problem for all buildings but is particularly well-characterised in non-domestic buildings (Innovate UK, 2016a & 2016b).
- Rented properties suffer from the so-called 'landlord/tenant divide': a principal-agent barrier where the landlord is reluctant to invest in energy efficiency measures (and as a result, respond to policy interventions) when the tenant benefits from the resulting lower energy costs.

- The construction sector faces significant supply-side barriers (Low Carbon Innovation Co-ordination Group, 2016; Zero Carbon Hub, 2014), such as fragmented supply chains, especially for large companies relying on outsourcing, unhelpful contractual conventions, poor management practice, a lack of the skills and capacity needed to specify and commission novel technologies and systems, and a general reluctance to try new approaches without prior demonstration.

A number of international policies and programmes are attempting to overcome these issues, and particularly the performance gap, by regulating operational energy performance as well the predictive approach used by conventional building codes. The Australian commercial building labelling scheme NABERS (The National Australian Built Environment Rating System) is a good example, although similar programmes are operating in the US and Singapore.

These programmes are attracting research attention because they are clearly transforming their markets. They appear to be doing this by raising the strategic important or 'salience' of energy savings by exploiting the value of other, non-energy 'multiple benefits' such as productivity, reputation, health, comfort or amenity (Mallaburn, 2016). However it is not yet clear how these processes work in detail or how this success can be replicated in a UK market or regulatory context.

Buildings policy in the UK

The UK was the first European country to introduce energy efficiency policies following the oil shocks in 1973 (Mallaburn & Eyre, 2016). Energy efficiency obligation policies were pioneered in the UK and used as a model for similar EU programmes in the late 1990s (Fawcett *et al*, 2018). However policy in recent years has stalled.

This section briefly outlines the recent history of buildings policy in the UK and the EU, sets out the current situation and assesses how the Clean Growth Strategy addresses the more serious policy gaps and shortcomings.

History

The period 2000-2010 saw a range of policies affecting buildings:

- Significant new funding for households through the Energy Saving Trust and (in 2001) a new Carbon Trust to support businesses and the public sector.
- An amendment to the England and Wales Building Regulations[2] requiring all domestic boilers fitted after 1st April 2005 to be condensing.
- A gradual tightening of the energy efficiency requirements of the Building Regulations, particularly in the 2006 revision in England and Wales[3].

2 Part L (England and Wales) has equivalents in Scotland (Part J) and Northern Ireland (Technical Booklets F1 and F2) – the exact dates of changes do not coincide.

3 Part L (England and Wales) evolved between 2002-2010 to make distinctions between residential / non-residential buildings and between new-build / existing buildings.

- The 2007 Carbon Reduction Commitment (CRC), requiring large non-energy intensive organisations to measure, disclose and manage their energy use.
- The 2008 Carbon Emissions Reduction Target (CERT) significantly ramped up the energy efficiency obligation on energy companies to subsidise energy efficiency measures.
- A 2008 requirement that all new buildings would need to be zero carbon from 2016 (households) and 2019 (commercial).
- Smart meters, and their roll-out by the Smart Meter Implementation Programme, established under the 2008 Energy Act.

At the EU level:

- The 2010 Energy Performance of Buildings Directive (EPBD) required Energy Performance Certificates (EPCs) to be provided at sale or lease to benchmark the theoretical energy performance of most buildings and give advice on energy efficiency options. Display Energy Certificates (DECs) measure actual energy performance in non-domestic buildings and must be prominently displayed in public buildings over 1000m^2 in floor area.
- EU product policy regulates the energy performance of technologies not regulated by the EPBD, mainly lighting and appliances. The two main measures are 2017 Energy Labelling Framework Regulation that governs the familiar A to G product labels and the 2009 Ecodesign Directive that sets minimum performance requirements to remove poorly performing products.

Current UK buildings policy

The UK and EU policies described above made a significant contribution to emissions reductions in the last 20 years, particularly in households (Committee on Climate Change, (2017). However, the Government's enthusiasm for buildings policy has waned since 2010 with many programmes being wound down or deprived of funding. This stop-start approach has been a characteristic of UK policy for over 40 years.

Policy for commercial buildings, which was never a UK strength, is now particularly weak, with a number of initiatives held back by industry lobbying or Government concerns about excessive burdens on business through the over-enthusiastic implementation or 'gold plating' of EU Directives (DCLG, 2015).

In 2012 direct, publicly-funded support for both business and household energy efficiency, estimated at around £100m pa, was removed from the Energy Saving Trust and the Carbon Trust (DECC, 2011). Conversely, support for public sector energy efficiency funding through Salix Finance has been maintained and, in 2017/18, significantly increased.

In 2013 the CERT energy efficiency obligation was replaced by the Energy Company Obligation (ECO) which stopped subsidies for better-off households and instead focused on the fuel poor.

In the 'able-to-pay' sector, CERT funding was replaced with the Green Deal, a repayable loan-based system aimed at overcoming up-front capital investment barriers. It was originally intended for both households and businesses, although most activity centred on the domestic sector.

The introduction of the Green Deal was widely recognised as a disaster both in emission reduction terms and, in combination with the removal of previous subsidies, by severely disrupting the retrofit market (Rosenow & Eyre, 2016). As Figure 4 shows, cavity wall and loft insulation rates have fallen dramatically compared to pre-Green Deal levels.

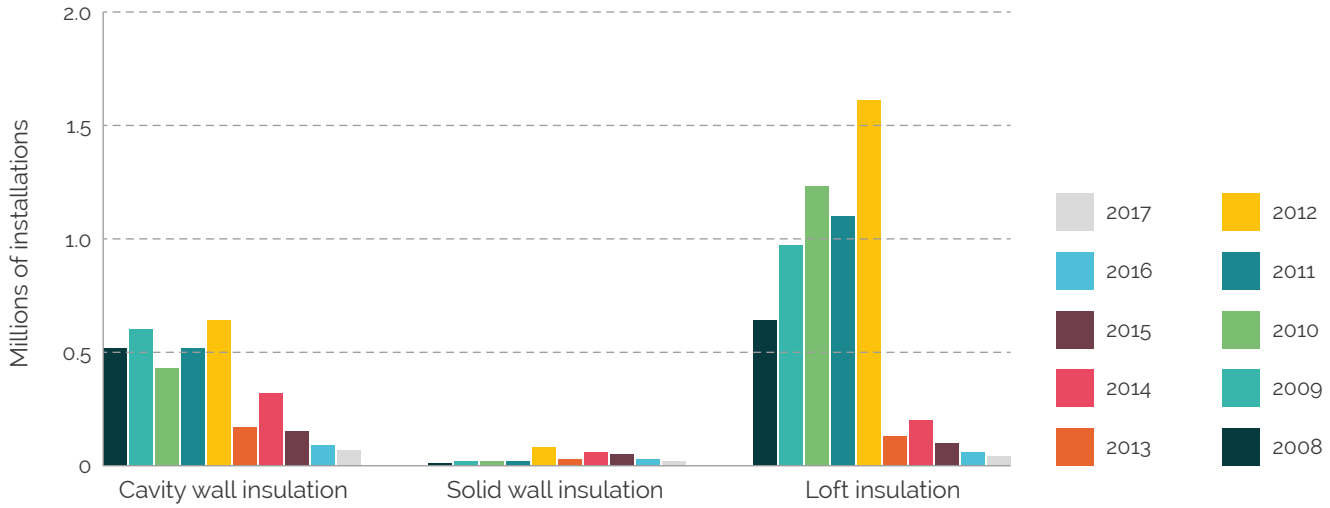

Figure 4. Annual insulation rates 2008-2017. Source: Reducing UK emissions. 2018 Progress Report to Parliament (Committee on Climate Change, 2018).

Zero carbon targets for both domestic and non-domestic buildings were abolished in 2015. The CRC Energy Efficiency scheme was fiercely resisted by businesses, progressively reduced in ambition and abolished in April 2019. Enhanced Capital Allowances for energy efficiency equipment will be abolished in April 2020 and the savings used to support a new industrial energy transformation fund for energy intensive companies.

Some new policies have been announced or enacted. For new buildings, in May 2018 the Prime Minister announced a 'Buildings Mission' to reduce energy use by 50% by 2030 (BEIS, 2018d). In the 2019 Spring Statement (HMT, 2019) the Chancellor announced a new Future Homes Standard which from 2025 effectively bans fossil fuel heating in new homes.

For existing buildings, the UK is developing its own operational energy performance scheme. From April 2019 all rented buildings are subject to minimum energy efficiency standards (MEES) under the Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015[4]. Rented properties must have an EPC rating of E or better unless the landlord registers an exemption. However, as discussed in the next section, the value of the EPC as a policy tool is open to question.

The grant regime under the Low Carbon Building Programme was replaced by feed-in tariffs under the Renewable Heat Incentive in 2011 where businesses and householders were paid according to the renewable energy they exported to the grid.

Several voluntary schemes are also under development for non-domestic buildings. The Soft Landings programme (BSRIA, 2012), developed by BSRIA, the buildings services trade body, aims to build capacity in the sector by providing guidance and support. The Design for Performance programme (Better Buildings Partnership, 2018), run by the Better Buildings Partnership, is piloting energy performance labelling, based on the Australian NABERS experience, in several large UK building developments.

Buildings in the Clean Growth Strategy

The Clean Growth Strategy (CGS), and subsequent initiatives related to it, proposes a number of new initiatives specifically aimed at households and non-domestic buildings.

Domestic buildings in the CGS

The key policy aim is to bring as many existing households as possible up to EPC band C by 2035 (where "practical, cost-effective and affordable") and 2030 for fuel poor and privately rented homes. This is an ambitious target, but the CGS does not explain how it will be delivered or funded. Also, there are no targets for new homes beyond the current Building Regulations. And finally, there are also significant concerns about the use of EPCs as a policy benchmark (Jenkins *et al*, 2017).

- A band C target is a blunt instrument. For hard-to-install measures such as solid wall insulation it may be more cost effective in the long run to upgrade to EPC band A or B at a relatively lower marginal cost compared with further intervention later.
- There are serious accuracy and reliability issues between different assessors, between different property types and within the same property type.
- An EPC uses annual fuel cost and annual carbon emissions as the main metric of evaluation. However, as we decarbonise energy supply this might become a less useful metric for managing demand compared to other metrics such as load flexibility at peak times.

4 MEES applies in England and Wales only. In January 2016, the Scottish Government published a draft of the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016 which came into force on 1st September 2016.

- There is compelling evidence that regulatory bodies are not enforcing current EPC rules (Environmental Industries Commission, 2018) or indeed Building Regulations more widely (Zero Carbon Hub, 2014).

The Hackitt Review of Building Regulations and Fire Safety (MHCLG, 2018), commissioned following the Grenfell fire, will significantly affect the regulatory environment in the UK. It is essential that this cultural change happens not only to fire and safety, but also energy performance. Several of the review recommendations, if implemented, would address the performance gap.

- A new Joint Control Authority separating enforcement from the interests of supply chain actors, including clients, designers and contractors.
- A stronger change control process that requires more robust record-keeping of changes made to plans during the construction process.
- More rigorous enforcement powers and penalties including requirements to change work that did not meet Building Regulations.

The use of regulations, if implemented correctly, can have significant benefits. Condensing boiler regulations are considered to be an exemplar. In 2003 they were in around 7% of UK houses. Once they were made mandatory in 2005, this rose to 50% in 2011 and is now approaching 100%, saving 11 MT CO_2e pa (Elwell *et al*, 2015) or 17% of total household gas consumption. There is potential for further savings at minimal cost such as managing flow temperatures and balancing heating systems. This latter measure can increase the efficiency of the system by 10% (Sustainable Energy Association, 2016).

Non-domestic buildings in the CGS

A Call for Evidence (BEIS, 2018b) estimated that the package of measures set out in the CGS would deliver £6bn in cost savings and 22Mt of non-traded CO_2 emission reductions, split 45% from existing policies, 40% from buildings and the remainder from industrial processes and heat. This, if implemented, would make buildings the single biggest new policy element for delivering the 5th Carbon Budget.

In common with domestic sector proposals the CGS is thin on actual policies to deliver this target. Only three are mentioned: a new energy performance reporting framework, an industrial energy efficiency scheme and tightening of the MEES standards. Key issues are deferred to future consultations: on advice for SMEs, the energy services and finance markets and the role of the UK Energy Savings Opportunity Scheme (ESOS) and Climate Change Agreements (CCAs).

Non-domestic buildings attract almost no specific policy attention at all: just 4 paragraphs, compared to 11 pages for households. There is no substantive analysis of the nature and scale of the problem or of the specific policies and measures that might be needed.

The Government's response to the Call for Evidence on business policies, published in March 2019, promises a review of Part L of the Building Regulations in 2019 and recognises the importance of focusing on operational performance, but also promises further consultations. It is fair to say that the Government does not have a non-domestic buildings policy.

There are some encouraging signs. The CGS recognises the central role of regulation coupled to demand-side drivers, building on research into corporate strategic or 'salience' drivers (DECC, 2012) and the International Energy Agency's 'multiple benefits' approach (IEA, 2014).

The Government recognises that policies to deliver their objectives must combine market solutions with strong Government intervention. This is important because the lessons from successful overseas policies (van der Heijden, 2017) show the value of a hybrid policy approach, where carefully managed government/industry partnerships are exploiting the multiple benefits of improved energy performance to transform markets (Mallaburn, 2018).

Recommendations

Recommendations for Government policy

HMT, BEIS, MHCLG and devolved administrations:
Develop an overall policy framework for the building sector that unifies the existing fragmented, stop-start policy approach and provides a clear signal of Government ambition and intent in the medium and long-term that will deliver the buildings element of future carbon budgets. If business is to invest in delivering this long-term strategy and develop new models it needs long-term Government commitment.

BEIS and MHCLG:
Ensure that the implementation of the Hackitt Review addresses the energy efficiency performance gap on the evolution of and compliance with buildings standards and in the development of skills, standards, procedures and capacity within the building industry sector.

BEIS and MHCLG:
Broaden overall policy on to the actual, real-world 'as-built' energy performance of buildings. Shifting to a performance-based culture will allow tenants and householders to choose energy efficient buildings and enable the market to accelerate their uptake.

- For households, regulatory policy needs to focus on actual rather than modelled heat loss from the buildings, based on the principles set out in the recent BEIS Smart Meter Enabled Thermal Efficiency Ratings (SMETER) project (BEIS, 2018c).
- For non-domestic buildings the Government should introduce a performance-based policy framework based on successful overseas experience.

BEIS:
Introduce measures to deliver rapid, low-cost emission reductions from existing technologies and systems, for example using product labels to reflect the real-world, operational boiler efficiency based on the Government's 'Boiler Plus' approach (BEIS, 2017).

BEIS:
Produce credible roadmaps for new and existing buildings on the deployment of emerging technologies such as heat pumps, district heating and solid wall insulation, identifying sectors to be used to reduce costs and build supply-chain capacity, for example heat pumps installed in properties off the gas grid.

Recommendations for CREDS and BEIS working together

Continue to develop and build national, long-term energy performance datasets. Policymakers and researchers need reliable, real-world, in-use energy performance data. Significant progress has been made in recent years by both Government and researchers, but many areas need urgent attention.

- For households, we need a national longitudinal survey building on existing data and monitoring, such as the EPSRC Smart Meter Research Lab and the MHCLG/BEIS English Housing Survey and its Energy Follow-Up Survey. Together these can provide a coherent platform to develop the national tool for domestic policy, the National Household Model.
- EPCs for the twenty-first century. EPCs are the main currency for delivering building energy efficiency and cost millions to implement. However, the implementation is poor in part because the latest computational, digital and data practices are not utilised.
- For non-domestic buildings we need a national data strategy to bring together and rationalise the various official datasets and studies building on the work of 3DStock and SimStock.

Maximise the value of research and demonstration investments. UK Research & Innovation, Government and industry have funded several major projects such as the EPSRC Active Building Centre and the Energy Systems Catapult Smart Systems and Heat programme. It is important that maximum value is extracted from these investments, for example to help develop data and modelling tools.

Deepen our understanding of how to exploit the value of the multiple benefits of energy efficiency. We need to understand how they enhance the salience of energy demand measures, how salience varies between organisations, sectors and individuals and where the key, practical policy 'intervention points' lie.

- For households we need systematic ways of capturing the value of multiple benefits in policy evaluations, for example based on HIDEEM modelling of the health benefits of energy efficiency (Hamilton *et al*, 2015), used for fuel poverty policy appraisal (BEIS, 2016).
- Develop methodologies to characterise and better understand the relationships between the thermal performance of buildings and indoor environmental quality (IEQ – air quality, over-heating and noise).
- For non-domestic buildings we need to understand how energy productivity and other 'multiple benefit' policy approaches can transform the buildings and construction sectors by, for example, exploiting value drivers and building market capacity and skills.

Develop a long-term collaborative hybrid policy framework to decarbonise buildings based on successful experience overseas and the latest research that sets out the respective roles of industry and Government over a 10–15 year timescale.

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