Low
Carbon
Innovation
Coordination
Group

Technology Innovation Needs Assessment (TINA)

Domestic Buildings
Summary Report

March 2016

Background to Technology Innovation Needs Assessments

The TINAs are a collaborative effort of the Low Carbon Innovation Co-ordination Group (LCICG), which is the coordination vehicle for the UK's major public sector backed funding and delivery bodies in the area of 'low carbon innovation'. Its core members (at the time of this document's completion) are the Department of Business, Innovation and Skills (BIS), the Department of Energy and Climate Change (DECC), the Energy Technologies Institute (ETI), the Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, Scottish Enterprise, and the Scottish Government.

The TINAs aim to identify and value the key innovation needs of specific low carbon technology families to inform the prioritisation of public sector investment in low carbon innovation. Beyond innovation there are other barriers and opportunities in planning, the supply chain, related infrastructure and finance. These are not explicitly considered in the TINA's conclusion since they are the focus of other Government initiatives.

The purpose of the TINAs is to help policy makers to plan and prioritise innovation support. A report summarising each TINA is published to provide transparency.

The TINAs apply a consistent methodology across a diverse range of technologies, and a comparison of relative values across the different TINAs is as important as the examination of absolute values within each TINA.

The TINA analytical framework was developed and implemented by the Carbon Trust with contributions from all core LCICG members as well as input from numerous other expert individuals and organisations. Expert input, technical analysis, and modelling support for this TINA were previously provided by Building Research Establishment (BRE).

Core members of the Low Carbon Innovation Coordination Group (LCICG):

Department for Business Innovation & Skills

Department of Energy & Climate Change

energy technologies institute

EPSRC Engineering and Physical Sciences Research Council

Innovate UK Technology Strategy Board

Scottish Enterprise

The Scottish Government Riaghaltas na h-Alba

This analysis was prepared for the LCICG by:

CARBON TRUST

Key findings

Innovation in the domestic buildings sector represents a significant opportunity to help meet the UK's greenhouse gas (GHG) emissions targets as well as providing value through avoided energy costs, amounting to carbon savings of 64 million tonnes of carbon dioxide ($MtCO_2$) (29-146$MtCO_2$) and energy savings of c. £18 billion (bn) (£8-42bn) by 2050[1]. Innovation could also help create domestic and export opportunities that could contribute a total Gross Added Value (GVA) of £1.7bn (£0.8-4bn) to Gross Domestic Product (GDP) to 2050, while supporting 1,000 (500-2,400) direct jobs per year by 2050. Public sector support will be required to unlock this value, as there are significant market barriers across the sector to overcome.

Potential role in meeting the UK's GHG emissions targets	• The energy used by domestic buildings in the UK accounts for approximately 22%[2] of the UK's total emissions. • Innovative energy saving measures in domestic buildings could save approximately an additional 14$MtCO_2$ by 2025 and 64$MtCO_2$ by 2050. • Across the technology areas considered (pre-construction and design, build process, building operation, and materials and components), innovations in building operation would save the most carbon, most quickly, predominantly from the existing building stock.
Value of abatement potential	• The potential net value from energy savings is c. £18bn (8-42bn) to 2050. The 12.5% increase from the original TINA value is primarily driven by the increase in energy prices. • Across the technology areas, innovations in building operation could yield most value. • Innovations in pre-construction and design, and build process could also yield significant value. • Innovations in materials and components will not provide significant value unless costs come down faster than expected, however improved and cheaper materials (e.g. thin insulation products) may amplify savings from other areas.
Green growth opportunity	• Additional global market value of innovative products in this sector could reach c. £173bn (£52-404bn) cumulatively over 2015-2050, of which c. £64bn (£21-148bn) would be accessible to the UK. Of this, innovative products could provide an additional £1.7bn (£0.8-4bn) in Gross Added Value (GVA) to the UK economy by 2050. Additionally, this market can support 1,000 (500-2,400) direct jobs per year in 2050, of which 600 jobs are related to domestic activity and 400 jobs are related to export activity.
The case for UK public sector intervention	• Market barriers exist across the buildings value chain, stifling innovation and progress in improving the energy efficiency of domestic buildings. These include a lack of high-quality data, split incentives between various actors, and regulatory uncertainty. • The UK cannot exclusively rely on other countries to develop the innovation needed. The UK is already a world leader in a number of technologies and also has unique requirements including climate, diversity of building stock and building usage patterns. • Construction services are generally delivered by local firms, so the UK will need to build capacity to implement innovative energy efficiency measures. • Gathering data on actual building performance in-use is vital and should be encouraged to understand the value of energy savings, as well as to innovate and implement measures effectively. Split incentives between different actors in the value chain currently prevents this from happening.

[1] Cumulative (2015-2050) 2015 GBP discounted values for medium (low-high) deployment scenarios and a high innovation scenario.

[2] Factsheet: Buildings, Committee on Climate Change (2015), The original TINA in 2012 mentioned 25%, which was cited from the 2005 Digest of UK Energy Statistics.

Potential priorities to deliver the greatest benefit to the UK	• Public sector support could provide most value in building operation innovations – due to the high value from energy savings – and in pre-construction and design innovations – where the UK is a world leader – due to high value and the presence of market barriers. • Support for elements of build process innovations could also provide significant benefit. • Support for materials and components innovations would provide some benefit, however the potential value and carbon saving would be significantly smaller than would result from support in other areas. • Although each technology area could be treated in isolation, they are interconnected, and realising the full benefit of investment will require an integrated approach supporting innovation in each area. • Retrofit represents significant opportunities in low carbon. Aside from a robust supply chain, innovation in business models and technologies is needed to enable refurbishment at scale. • More systematic knowledge sharing would be useful in creating and shortening the feedback loop of performance information necessary to drive innovation and improve overall performance across the buildings value chain.

2015 Refresh

Most of the analysis in the original TINA published in 2012 is still relevant today. The original findings on innovative measures, market barriers, and innovation priorities and support remain valid and hence are unchanged. The refresh expands on original findings, updating the original text with specific details in the sections on market barriers and innovation priorities.

External to the buildings boundary, recent technology developments have enabled buildings to play a more active role in the energy system. This refresh also comments on further innovation needs in integration and interfacing with heat networks and the wider built environment. Energy management systems are part of the scope of this TINA, although heat management systems are also discussed in the Heat TINA. The specific hardware related to heat (such as heat pumps, heat networks, and heat storage) are discussed and analysed in the Heat TINA, The smart controls discussed here in the Domestic Buildings TINA does have some minor cross-over with the heating controls element also discussed in the Heat TINA.

The refresh also updates activities/investments that have been happening across the LCICG. Examples of international activities that are relevant to the key needs for domestic buildings are also mentioned.

The refresh has revised the quantitative analysis of carbon savings and energy savings values with up-to-date emission factors and energy prices. Calculated savings are adjusted to 2015 terms. The refresh also performs additional analysis on the GVA (Gross Value Added) supported by the deployment of domestic buildings innovations with domestic and export activity separated out. Jobs supported figures, which were not included in the original analysis, are also provided.

Finally, the multitude of buildings stakeholders and the relatively low current cost of technologies implies that cost reduction in technologies alone is not sufficient, and policy and regulation has a key role to play in encouraging technology uptake. Multiple experts interviewed for the refresh echoed this view, however policy options beyond innovation support are outside the scope of the TINA methodology and will not be discussed here.

Chart 1 - Domestic buildings TINA summary

Technology area	Value of energy saving (£bn)[3]	Value in business creation (£bn)[4]	Direct jobs supported in 2025/2050[5]	UK competitive advantage	Potential public sector interventions
Pre-construction and design	3.5 (1.6 – 8.1)	0.7 (0.3 – 1.5)	1580/560	Medium-high	• Prize funding challenge to develop tools for enhancing energy modelling techniques. • Early pre-commercial demonstration programme for modelling tools and techniques. • Establish consortia for retrofit tools. • In-use data collection programme for highly-rated buildings. • Convened consortia including major social landlords and professional bodies to define and demonstrate new practices, combined with knowledge sharing activities.
Build process	4.5 (1.9 – 9.5)	0.2 (0.08 – 0.4)	340/150	Low-medium	• Collaboration for evaluation and demonstration of off-site construction and industrial retrofit. • Research and development of standard and community scale retrofit models. • Support development of standard models that will be appropriate for different building and tenure types. • Trial commercial model for community-scale refurbishment. • Better ways to identify retrofit opportunities, calculating potential market value and devising action plans. • Tools that integrate design across the construction team e.g. taking account of the change of team responsibility as the project proceeds.
Building operation	9.2 (4.6 – 23)	0.8 (0.4 – 2)	600/300	Medium	• Collaborative research and development for smart controls with a focus on making them easy to use for the occupiers. • Incubation programme for methods to encourage behavioural change. • Information dissemination programme. • Data collection programme for highly-rated buildings. • Research to evaluate the effectiveness of innovative systems on influencing householder behaviour.
Materials and components	0.7 (0.3 – 1.3)	0.03 (0.01 – 0.06)	160/40	Medium	• Challenge-based collaborative research and development (R&D) in early stage fabric technologies aimed at improving performance. • Prize funding for integration of later-stage technologies into real refurbishments combined with pre-commercial field trials to scale-up. • Field trials considering most efficient rated buildings, to see why they are performing better than average.
Total[6]	**18 (8 –42)**	**1.7 (0.8 – 4)**	**2700/1000**		

Benefit of UK public sector activity/investment[7]	High	Medium	Low

[3] 2015-2050 medium (low – high) deployment with marginal cost of technology included to calculate value.

[4] Total GVA to UK economy with displacement 2015-2050.

[5] Jobs supported in 2025 and 2050 are based on direct jobs only using Office of National Statistics (ONS) figures for jobs per £ million turnover for each sub area based on the turnover captured by the UK. Some of the technology areas have a smaller figure in 2050 when compared to 2025 due to reduced uptake as the technology becomes saturated.

[6] Due to rounding, numbers presented throughout this document may not add up exactly.

[7] Also taking into account extent of market barrier, UK competitive advantage and opportunity to rely on other countries.

Energy efficiency in domestic buildings has an important role to play in meeting the UK's GHG emissions targets

The energy used in domestic buildings accounts for approximately 22% of UK carbon emissions[8]. The existing building stock itself is diverse in age, building type, tenure, and energy efficiency.

There are strong policy ambitions in the UK affecting domestic buildings. The Climate Change Act 2008 requires an 80% cut in emissions by 2050, and a significant part of this must come from the domestic buildings sector.

Given that three-quarters of domestic buildings that will exist in 2050 have already been built,[9] strong attention also needs to be given to improving the performance of the existing domestic buildings stock, both by using existing buildings more efficiently, and though refurbishment.

Research has shown that there is often a gap between the design intent of a building and its actual performance[10]. Overcoming this gap will require an integrated approach taking into account the way buildings are used, as a system whose value is greater than the sum of its parts, and where interaction with householders is critical.

Innovative measures could benefit the entire building lifecycle. Ensuring that new buildings are constructed and used as designed will require process innovations (i.e. quality control and compliance arrangements), and innovative tools and systems to enable processes, while improving the physical performance of new and refurbished buildings will require innovations in building technology.

Also significant, though beyond the scope of this TINA, is the wider context in which low carbon buildings sit. Other TINAs consider these, in particular Heat, and Electricity Networks and Storage.

We have considered three deployment levels of innovations in domestic buildings. The amount of energy saved will depend upon the extent to which innovative measures can be applied to the domestic building stock (applicable to existing buildings, new builds and major refurbishment) in the UK, so this is the variable that is altered in the scenario analysis.

Regulatory 'push' and market 'pull'

Policy has a key role to play in enabling technology uptake; policy signifies government commitment and encourages private sector investment in innovations by creating additional market demand.

From the market's point of view, the feasibility of low carbon technologies depends on a long-term sustainable pipeline of demand. Through policy, government can incentivise innovation by providing greater certainty for this pipeline. Standards and regulations are important to ensure conformity across the buildings value chain.

While appropriate policy support is important, the, buildings value chain also needs to respond. Owners and users of the asset need to better recognise the benefits of energy efficient buildings. These energy efficiency measures will not just contribute to the bottom line, but also bring a whole host of co-benefits, e.g. health, safety, and poverty reduction. The business opportunities available through the uptake of energy efficient technologies will be tremendous, and the buildings industry needs to acquire the skills and tools to better address these demands with innovative and robust business models.

The extent of deployment will depend significantly on regulatory 'push' and market 'pull'. The scenarios used in the TINA are based on policy and market needs:

- **Low scenario** – depends on effectiveness of policy measures in existing buildings, new build and refurbishment rates that allow improvement in stock, and perception of measures as low risk (from energy and carbon prices and cost of measures).
- **Medium scenario** – as above, plus strong market demand for low carbon buildings, a supportive legislative framework and structured processes for gathering feedback on actual performance.
- **High scenario** – as above, plus strong political focus coupled with a highly skilled industry, and householder co-operation.

These are compared with a counterfactual scenario, which assumes that the grid is decarbonised and existing cost-effective commercial measures are implemented.

The medium scenario is used as the central scenario for the following analysis.

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[8] Committee on Climate Change, Factsheet: Buildings, 2015, https://www.theccc.org.uk/wp-content/uploads/2014/08/Fact-sheet-buildings-updated-July-2015.pdf

[9] Low Carbon Construction Innovation and Growth Team, final Report (2010).

[10] Wingfield *et al*, "Lessons from Stamford Brook – Understanding the Gap between Designed and Real Performance" (2008), Leeds Metropolitan University.

Buildings in the wider UK energy system

In 2013, domestic buildings represented 22% of UK energy use with annual emissions of 135MtCO_2e, of which, space heating, water heating, cooking, lighting, and appliances contribute 66%, 17%, 2%, 3%, and 12% respectively[11]. Under a business as usual scenario, domestic buildings' energy demand will increase by 14% to 566 Terrawatt hours (TWh) in 2050[12]. Innovative measures can deliver up to 391TWh (181-902TWh) of cumulative energy savings by 2050 relative to 2015. Innovation and adoption of new technologies can reduce demand to the energy system by either improving energy efficiency in existing buildings, or reducing the capacity of energy appliances in new buildings through better design.

The buildings energy services – heating, cooling, and lighting – utilise natural gas, grid electricity, and oil with different fuel mixes in different buildings. Electricity emission factors reduce significantly in 2050 due to a decarbonised grid. This TINA analysis incorporates emissions factors reported by DECC[13] but savings from a decarbonized grid do not count towards energy savings reported in this document.

For heating energy services, better heating networks and the use of storage will reduce demand, and the deployment of heat pumps will further decrease space heating emission factors.

Recent innovations have transformed the position of buildings in the energy system from the conventional energy receiver to a more integrated player. Due to technology advancement, buildings in the future can play at least two additional roles:

- Power generation, by incorporating energy gathering technologies into the buildings boundary, such as solar photovoltaics (PV), combined heat and power (CHP), and heat pumps;
- Demand response and storage, by shifting or reducing electricity use during peak load to reduce the burden on the external grid. This requires wide adoption of advanced control systems.

These effects are excluded in this analysis due to the scope of this TINA, but are considered in the Heat TINA and Electricity Networks and Storage TINA.

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[11] Energy consumption in the UK, DECC (2015); Factsheet: Buildings, Committee on Climate Change (2014); Carbon Trust analysis.

[12] BRE analysis.

[13] Valuation of energy use and greenhouse gas (GHG) emissions: Supplementary guidance to HM Treasury Green Book on Appraisal and Evaluation in Central Government, DECC (2014).

Description of innovative measures

The innovative measures in this TINA are additional to existing commercial measures. Innovations for domestic buildings can be split into four major technology areas: pre-construction and design; build process; building operation, and materials and components.

Pre-construction and design innovations include:

- **modelling and software tools,** which could become faster and more accurate in maximising the use of passive design strategies;
- **tools to identify retrofit opportunities quickly, cheaply and accurately –** measures that minimise intrusion to identify opportunities in existing buildings to improve energy performance e.g. heat cameras linked to vehicles or laser surveying tools allowing insulation panels to be pre-assembled;
- **design tools and services** providing greater expertise and knowledge in domestic buildings and their services to complement micro-generation and district heating, to allow their integration during construction works or simplify their adoption as a future retrofit measure.
- **ancillary tools**, such as decision support tools, operational profiles, rating and certification tools, calculator tools for quantitative and qualitative information, and guidelines for the integration of processes.

Build process innovations include:

- **smart manufacturing processes,** e.g. off-site construction, where individual modules are pre-manufactured and assembled on-site, and modern on-site construction and manufacturing, and tighter supply chain integration;
- **industrialised retrofit techniques**, better ways to identify retrofit opportunities, calculating potential market value and devising action plans, new construction methods to reduce the cost of refurbishing existing buildings and improving the performance of refurbished buildings.

Building operation innovations include:

- **smart controls and systems diagnostics,** predictive, intelligent householder-oriented building controls and diagnostic applications that optimise performance of building services (e.g. central heating);
- assisting **behavioural change** by providing users with clear information, incentives and innovative tools with which to interact with buildings.

Materials and components innovations include:

- **improved fenestration**, to improve the functional performance of windows to provide appropriate levels of light, insulation, shading and ventilation;
- **advanced insulation products,** lighter-weight, thinner, cheaper insulation to meet the increasing standards of Part L Building Regulations and the Code for Sustainable Homes – these may include solid wall insulation or more advanced phase change and nano materials;
- **low carbon cooling and ventilation,** a variety of technologies to service buildings with lower energy demand: natural ventilation methods, ventilation heat recovery and other techniques to replace conventional technologies and solutions.

Calculating the magnitude and value of energy and carbon savings

Innovative measures can provide energy savings additional to those achievable from the existing commercial measures included in the counterfactual.

Total savings achieved from each innovation are derived from a number of assumptions:

- the **uptake** of the innovation, i.e. the maximum proportion of existing domestic buildings to which the innovation can be applied;
- the **energy saving potential** of the innovation as a proportion of existing energy demand for each end use (e.g. 10% saving from lighting);
- the **lifetime**, and **performance at end of life** as a proportion of original performance (known as 'persistence') of the innovation;
- the **time to reach uptake** – a measure of the market's ability to implement the innovation;
- the **year of introduction** of the innovation, and
- the **roll-out period** for the innovation in existing buildings – a measure of the rate at which the innovation can be implemented in existing buildings based on refurbishment cycles.

Innovative measures are not replaced at the end of their life, as these measures will no longer be considered innovative once they are due to be replaced. Attributing further savings resulting from replacement of these measures may be counting savings that would happen anyway, without public sector support.

Uptake rates are defined according to the building type to which the innovations will be applicable – existing buildings, new builds and major refurbishments. For example, pre-construction and design innovations are not applicable to existing buildings; they are applicable to new buildings and major refurbishments.

Energy saving potential is divided into both building type and energy end use (heating, lighting or cooling). For example, build process innovations in new buildings may reduce energy demand from space heating by 50%, but by only 20% from cooling.

While building types are treated similarly for analytical purposes, each faces different challenges to deployment, which are discussed in more detail later.

Energy savings are calculated by multiplying the number of buildings by uptake rate and energy saving potential. Carbon savings are then calculated from these energy savings using projected carbon emissions factors[14].

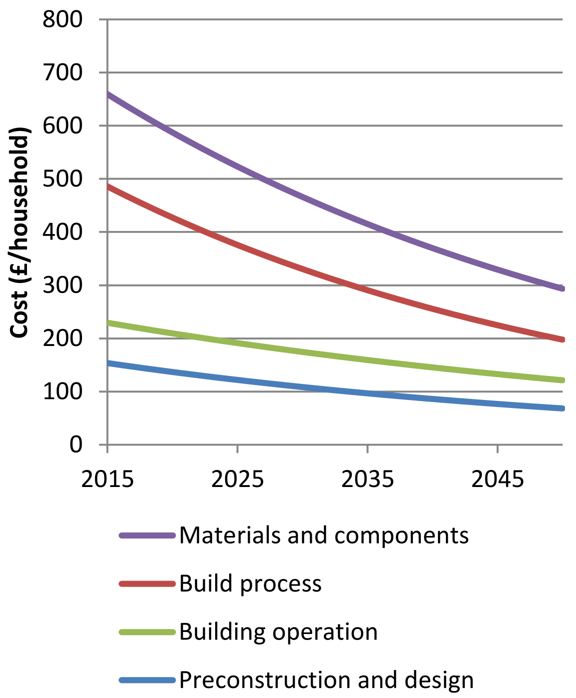
Costs

For most innovations, there is an increase in overall costs associated with additional services or higher quality materials. The cost assumptions used in this analysis are this additional cost. Costs reduce over time with increased levels of uptake and technical advances that reduce the cost of implementation.

- **Pre-construction and design** – additional costs for design tools and software supporting building services.
- **Build process** – costs of new materials and specialist skills anticipated to be marginally more than conventional products.
- **Building operation** – additional costs for software, controls and information systems.
- **Materials and components** – additional costs for materials (e.g. insulation) and processes (e.g. air-tightness details).

Costs are modelled to reduce proportionally to total deployment of each innovation – each time treated floor area doubles, cost reduces by 10%, as shown in ***Chart 2***.

Chart 2 - Aggregate costs of innovative measures in domestic buildings[15]



[14] DECC IAG data.

[15] BRE, Carbon Trust analysis.

Innovative measures could save an additional £18bn[16] and 64MtCO_2 by 2050

These savings would result from energy savings of 375TWh, or 2.6% of counterfactual energy demand. The increase from the original TINA value of £16 billion is primarily driven by the increase in energy prices.

Chart 3 summarises carbon savings and value from energy savings, while ***Chart 4*** shows the annual carbon savings resulting from these energy savings.

Innovations in pre-construction and design could save £3.5bn and 14MtCO_2 by 2050

Innovations in pre-construction and design are slow to realise savings as they are constrained by the new build rate of domestic buildings. For the same reason, savings are initially small, but continue increasing as more domestic buildings are constructed.

As energy prices are modelled to be higher in the latter half of the timeframe considered, value from energy savings is also significant.

Innovations in build process could save £4.5n and 22MtCO_2 by 2050

Build process innovations are limited by the new build and major refurbishment rates and are also slow to realise savings. Build process innovations are among the most significant of the technology areas considered in terms of carbon savings and value from energy savings. This is due, in part, to high uptake rates in new build and refurbished stock.

Innovations in building operation could save £9.2bn and 24MtCO_2 by 2050

Savings are very large and could be achieved quickly, due to the significant proportion of the domestic building stock that could benefit from building operation innovations. While savings could decrease beyond 2030 due to assumptions regarding grid decarbonisation and the relatively short lifetimes of building operation innovations, savings are so significant in earlier years that building operation innovations could provide the largest carbon savings and the greatest value from energy savings overall.

Note that these high savings are due in part to the fact that three quarters of buildings that will exist in 2050 have already been built, and assume that householders have sufficient incentive to implement measures as quickly as the market can deliver them. Deployment, and therefore savings, would be significantly curtailed without such an incentive.

Note also that these savings are reliant on energy performance improvements due to smart systems occurring as well as expected. More research into the effects of such systems is needed, as the interactions between householders and such systems are complex and not yet fully understood.

Innovations in materials and components could save £0.7bn and 4MtCO_2 by 2050.

Savings from innovative products and systems are significantly smaller than other innovations. They are assumed to become effective later and are generally only applicable in specific certain circumstances, and so have very low uptake rates.

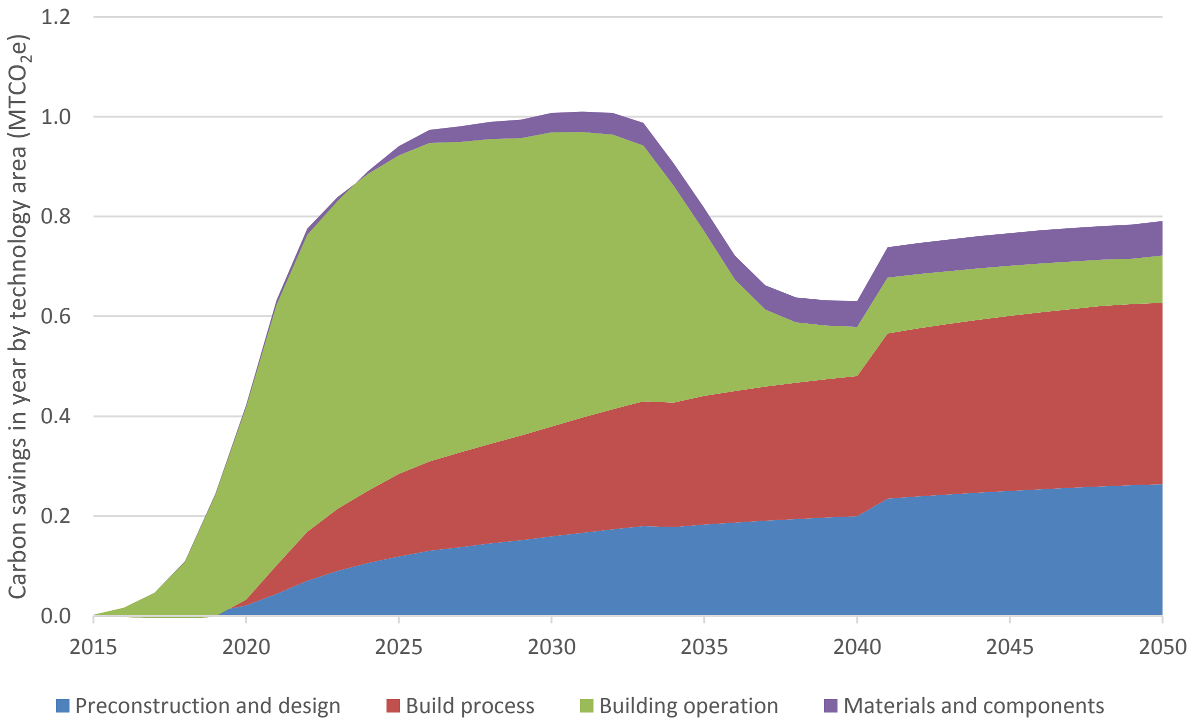
Value from energy savings is also low due to the high cost of measures, though this would be larger if costs come down faster than modelled.

[16] We have not considered the value of avoided carbon emissions to ensure consistency across the TINAs, however the presence of an applicable carbon price would increase the value of innovative energy efficiency measures.

Chart 3 - Summary of abatement potential and value of innovative measures[17]

Technology area	Carbon savings from 2015 to 2025 ($MtCO_2$)	Carbon savings from 2015 to 2050 ($MtCO_2$)	Net present value (NPV) of energy savings from 2015 to 2050[1] (£bn)			NPV per tonne CO2 saved (£/tCO2)	NPV per MWh saved (£/MWh)
			Low	Medium	High		
Pre-construction and design	1.6	14	1.6	3.5	8.1	244	40
Build process	2.8	22	1.9	4.5	9.5	205	35
Building operation	9.7	24	4.6	9.2	23.0	387	66
Materials and components	0.3	4	0.3	0.7	1.3	186	31
TOTAL	**14**	**64**	**8**	**18**	**42**		

Chart 4 - Annual carbon savings[18]



[17] BRE, Carbon Trust Analysis.

[18] BRE, Carbon Trust Analysis.

Green growth opportunity

The global market[19] for innovative products is estimated to be c. £173bn(£52-404bn) to 2050

The global market size for innovations in the domestic buildings sector is estimated using the available value from energy savings as a proxy for the additional cost the market would be willing to bear for the innovations. The global market value is scaled up using the ratio of estimated global floor area to UK floor area. It is assumed that developed countries have markets that are similar to the UK, with similar future requirements[20]. It is also assumed that the market for innovative measures in BRIC (Brazil, Russia, India and China) countries will start from 2020 and then evolve at a similar rate as that assumed for developed countries. Other developing countries are assumed to have limited markets for technologies that support very low carbon buildings and are excluded from global market calculations.

It is also assumed that the market would be willing to pay 25%[21] of the potential value through energy savings in order to realise them, though in reality this figure will vary by technology.

Only part of the global market will be accessible to the UK, given the generally domestic nature of the construction industry, with the accessibility of each technology area varying on its tradable portion.

The tradable portion for **pre-construction and design** is estimated to be 60% of the global market. Although building energy modelling software and other tools are tradable globally, design services tend to be delivered by local professionals, and some design services are only appropriate for countries with similar climates and construction techniques. There is significant scope for exportable equipment and intellectual property rights (IPR).

The tradable portion for **build process** is estimated to be 30%[22] of the global market. Building products, components and building services tend to be used in or close to those countries where they are manufactured, though there are global opportunities for exporting (IPR), skills and specialist tools, specialist components, services, and construction approaches.

The tradable portion for **building operation** is estimated to be 30%[23] of the global market. The export value of many services or associated software and hardware is likely to be low. The market for specialist products and services is global, and for some of these markets, the English language is an advantage. The provision of some services (e.g. audits) will be largely limited to local providers but there may be some IPR with export value.

The tradable portion for **materials and components** is estimated to be 60%[24] of the global market. Many of the potential innovations, in the form of new products or materials, professional expertise and design tools, have worldwide applications and some technologies are likely to have a large market overseas. There is also significant scope for exportable equipment and IPR.

UK competitive advantage

The UK has various strengths that would allow it to take advantage of the accessible market opportunity in each technology area.

The UK has a **medium-high** competitive advantage in **pre-construction and design**, estimated to be 10% of the accessible market. The UK is a global leader in building information modelling (BIM), there is widespread use of energy modelling amongst UK practices and there is active research and development in energy modelling. Low carbon cities around the world also use UK expertise, standards and best practice tools.

The UK has **low-medium** competitive advantage in **build process**, estimated to be 3% of the accessible market. There is growth in the uptake of off-site construction in the UK together with active government support and research by UK universities, however there is significant competition from other countries in build process innovations.

The UK has **medium** competitive advantage in **building operation**, estimated to be 5% of the accessible market. The smart controls and systems market is mature in the UK and strongly linked with the IT industry, where the English language is an advantage. There is UK capability in many areas, but services could be carried out locally, though there may be some IPR export value.

The UK has **medium** competitive advantage in **materials and components**, estimated to be 4% of the accessible market. The UK is a leader in many innovations that may have global applications, which could provide value in export of products and IPR.

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[19] The original TINA in 2012 refered to the global market value as a net present value of technologies deployed, whereas this refresh use turnover as market value, the like for like figure comparable to the previous TINA's market value of £620bn is £693bn.

[20] Developing countries based on the UN Human Development definition.

[21] Assumption based on expert interviews and modelling.

[22] Assumption based on expert interviews and modelling.

[23] Assumption based on expert interviews and modelling.

[24] Assumption based on expert interviews and modelling.

Contribution to the UK economy

The GVA to the UK economy is calculated by:

1. Multiplying the accessible market by the UK's competitive advantage to give the tradable turnover captured by the UK.
2. Adding the non-tradable portion of the market that relates specifically to UK deployment to give the non-tradable turnover captured by the UK.
3. Turnover figures are then multiplied by a GVA:Turnover ratio[25] (which differs by technology area) and a displacement factor[26] to give GVA figures.

The GVA contribution of **innovative measures in domestic buildings** UK economy is c. **£1.7bn (£0.9-4bn)**, of which export GVA is **£1bn (£0.3-2.1bn)** and domestic GVA is **£0.7bn (£0.2-1.6bn).** Direct jobs in 2025 are estimated at **2**,**700 (1**,**200-6**,**200).** Due to the exclusion of technology replacement, uptake of technologies will plateau as they reach their maximum uptake, and therefore annual turnover in 2050 is less than in 2025. The direct jobs supported in 2050 are estimated at **1**,**000 (500-2**,**400).** There is additional value not captured by this figure, including maintaining (or increasing) UK competitiveness in the construction industry to capture future value, and the provision of associated but non-innovative services.

[25] *UK Non-Financial Business Economy (Annual Business Survey), ONS (2012).*

[26] Part of the value created in the buildings sector will be due to a shift of resources from elsewhere in the economy and thus partly cancelled out by a loss of value in other sectors. Expert opinion has roughly assessed this effect to be between 25% and 75%, so we have applied a flat rate of 50%.

The case for UK public sector intervention

To capture the value from these technologies, there is a strong case for targeted public sector intervention, especially where there are evident market barriers. The following section analyses the need for intervention based on the extent of market barriers and analyses opportunities to rely on others.

Market barriers impeding innovation

There are many overarching market barriers across each technology area, though individual innovations also face specific market barriers. Overarching market demand barriers include:

- **Energy costs are seen as immaterial** – householders may not be willing to change their behaviour or make improvements to buildings because the energy savings are considered negligible. This has had a particular impact in recent years as the prospect of tighter regulation driven by carbon savings appears to be waning. The implication for innovators is that business cases cannot be based on energy cost savings alone.
- **Poor access to finance** is likely to suppress demand for innovative measures for the minority of households whose energy costs are material.
- **The landlord-tenant divide** – affects tenanted properties, where one party has no incentive to invest in energy saving measures as the other party receives the benefit, also known as a 'split incentive'.
- **Complex planning requirements surrounding the self-build industry**, which could otherwise provide opportunities for buildings to use innovative materials, designs and building methods – obstacles to self-build include access to land and sourcing architectural and planning services. Self-builders lack a single point of contact that can provide integrated solutions.
- **Fragmented industry –** the burden of gathering information and liaising with various contractors to pursue a retrofit is often on the householder.
- **Lack of regulatory certainty around compliance** - few of those engaged in building new homes – from designers and product manufacturers to developers and contractors – can or will invest to the greatest extent in the development of solutions to achieve carbon compliance to zero carbon standards until they know the metrics by which their work will be measured. Non-enforcement of existing regulations could in part be driven by the costs of enforcement, which could be mitigated by the development of better verification tools. As with much regulation, consistency is often as important as the actual shape of the regulation, for example the changing definitions of the zero-carbon standard.
- **Lack of certainty around Government policy,** which may be preventing investment in innovation.

Additionally, there are a number of supply conditions influencing market barriers:

- **The building sector is conservative** and reluctant to adopt new approaches without clear prior demonstration or regulatory drivers.
- **Low carbon measures** generally cost more, which is prohibitive to smaller firms due to their lack of economies of scale and the difficulty in transferring these costs as value add to their customers.
- **There is a lack of necessary skills** and experience required to implement novel technologies.
- **Existing conventions around contracting have a negative impact** on low carbon outcome. There is no requirement for the construction industry to fix mistakes, as actual performance may not be a contractual requirement. Nor is it easy to measure or prove a cause of worse than expected energy performance.

Although these overarching market barriers affect all innovation, there are specific barriers, which vary within each technology area, summarised in ***Chart 5***.

Critical barriers in modelling and software are due to the lack of high quality data and the lack of incentives to share what data there is. Furthermore, developers do not conduct modelling incorporating unregulated demand (demand arising from appliances), and some modelled designs are difficult to build without error.

Barriers in adopting new technologies

- Considering the need for business cases to be based on more than just energy costs, data collection is failing to capture and feed back co-benefit information (e.g. health, safety, and poverty reduction).
- Most of the advanced low carbon buildings innovations applied in the UK are from European-based product manufacturers or service providers. Hence their product research will prioritise their home country building stocks. This means the UK will require additional demonstration and adaptation trials to integrate innovations.
- Product certification processes are lengthy and expensive, leading to delays in innovative products being applied in the UK. Related to this, contractors are reluctant to accept new technology and insurance providers, and mortgage suppliers are conservative and perceive new technology as adding additional risk.

The UK cannot rely on other countries to drive innovation with the required focus and pace

In some cases, innovation needs may be similar in other countries, such that the UK could rely on these countries to develop innovative measures instead. There are two kinds of innovation activity, which may be needed: research and development, and demonstration and adaptation.

In general, the UK could rely on other countries for some research and development activities, particularly at earlier stages before demonstration and adaptation. However, this is not the case for pre-construction and design innovations where the UK is already a world leader.

Pre-construction and design innovations would also need to be explicitly tailored for UK needs, based on the building stock and climate conditions. This is also true for products and systems (such as developing advanced natural ventilation systems) as the UK has very specific needs, which would require specialist research.

Given that the UK has a unique set of characteristics, and given that buildings are largely constructed by domestic firms, any innovation will need to be demonstrated and adapted specifically to local needs. As the UK cannot rely on other countries to adapt innovations to its own needs, nor import industry learning due to difficulty, UK activity will be required.

Furthermore, while other countries may deliver early stage R&D solutions in build process, building operation, and materials and components, the UK has a leading competitive edge in several specific aspects. These include energy management systems, software and design tools, passive/low-carbon, heating and cooling, and discrete technologies such as micro fuel cells and PV coatings built on the strong universities, research and technology organisations, and innovation support in these areas.

Chart 5 - Market barriers in domestic buildings innovation areas

	Sub area	What market barriers exist?	Extent of market barrier
Pre-construction and design	Modelling and software	• Incomplete information regarding actual building performance (especially refurbishment). • No incentives to share learning (combined with inconsistency in their application and non-compliance). • Fragmentation of the supply chain.	Critical barrier
	Tools to identify retrofit opportunities	• Lack of information on performance of existing buildings as compared with new build. • Identification and retrofit actions will need to make use of existing triggers (e.g. remodelling a bathroom). • Tools would need to be very sophisticated to see widespread uptake, however tools are currently poorly developed.	Critical barrier
	Design tools and services for district heating	• The UK has very limited district heating infrastructure, resulting in lack of information and experience.	Moderate barrier
Build process	Smart manufacturing processes	• Off-site production is fragmented and dominated by relatively small companies • Volatility in the demand for factory output. • Energy efficiency is often not the incentive for off-site and smart construction.	Minor barrier
	Industrialised retrofit techniques	• Refurbishing domestic buildings incurs a high 'hassle cost' meaning that householders are unlikely to carry out significant measures without incentives. • Split incentives between landlords and tenants. • Lack of materiality of energy costs. • Lack of data to identify retrofit opportunities.	Significant barrier
Building operation	Smart controls and diagnostics	• Lack of materiality of energy costs does not encourage householders to alter their behaviour in order to save energy. • Split incentive between landlords and tenants results in a lack of incentives for owners to invest in such controls if they are not householders. • Lack of high quality data may prevent optimal design of controls and may prevent householders from becoming aware of where behavioural change may be able to reduce energy consumption.	Significant barrier
	Behaviour change	• Lack of materiality of energy costs does not encourage householders to alter their behaviour to reduce energy consumption. • Lack of high quality data may prevent householders from becoming aware of where behavioural changes may be able to reduce energy consumption. • Challenges in communicating energy performance data to householders.	Significant barrier
Materials and components	Improved fenestration	• Low perceived benefit and high cost. • Would involve significant disruption during refurbishment.	Moderate barrier
	Advanced insulation and thermal materials	• Diverse nature of the building stock makes standardisation difficult. • Inadequate incentives given high costs involved. • Lack of knowledge about available systems and their importance to performance. • Regulatory and insurance hurdles are significant for use of overseas technologies and materials. • Product certification process for new innovations are time consuming and expensive.	Critical barrier
	Passive low carbon cooling and ventilation technologies	• Inadequate incentives to secure investment needed to address technology barriers and reduce cost. • The perceived risk of trying new technologies may dis-incentivise their use in favour of existing 'tried-and-tested' measures.	Significant barrier

Potential priorities to deliver the greatest benefit to the UK

The UK needs to focus its resources on the areas with the biggest relative benefit to the UK, and where there are no existing or planned initiatives (both in the UK and abroad).

The original TINA illustrated potential innovation priorities and support for the UK. Some of the key needs underpinning these priorities have been directly addressed by Innovate UK programmes, for example “A digital tool for BIM” addressed the need for design tools and services. Innovate UK programmes also addressed market barriers identified in the previous TINA, for example “Supply Chain integration in Construction” was intended to address the fragmented supply chain market barrier. Public sector activities/investment since the original TINA are summarised in ***Chart 6***.

As a result of these activities, some of the priorities identified in the original TINA have been revised in this refresh to reflect progress and better capture the aspects of these priorities that remain relevant. The 2015 refresh has also updated the innovation priorities to:

- Focus on specific areas, e.g. smart controls that are more user friendly;
- Capture new aspects of needs that have emerged due to recent developments, e.g. ancillary tools that support preconstruction and design and interface protocols to enable controllers to communicate with each other; and
- Broaden the scope to include other priorities, e.g. embodied carbon and benchmarking guidance.

While all technology areas in the domestic buildings sector would benefit from public sector activity, some would benefit more than others. ***Chart 7*** summarises the areas that would receive greatest potential benefit from UK public sector activity across all technology areas.

Chart 6 - Summary of UK public sector activity/investment since the original TINA was published

	Activities	Key needs/market barriers addressed
Pre-construction and design	• Innovate UK “A digital tool for BIM”. • Innovate UK “Buildings, better connected”.	• Design tools research development & demonstration
Build process	• DECC/Innovate UK “Invest in Innovative Refurbishment”. • Innovate UK “Supply chain integration in construction”. • Innovate UK “Digitising the Construction Sector” programme. • Innovate UK/EPSRC “Building whole-life performance”.	• Industrialised retrofit technique • Fragmented supply chain • Lack of knowledge and skills • Unreliable commissioning
Management and operation	• Innovate UK “Future Energy Management for Buildings”. • Innovate UK “User Centered Design”.	• Smart controls • User behaviour change

Chart 7 - Summary of greatest potential impact from UK public sector activity[27]

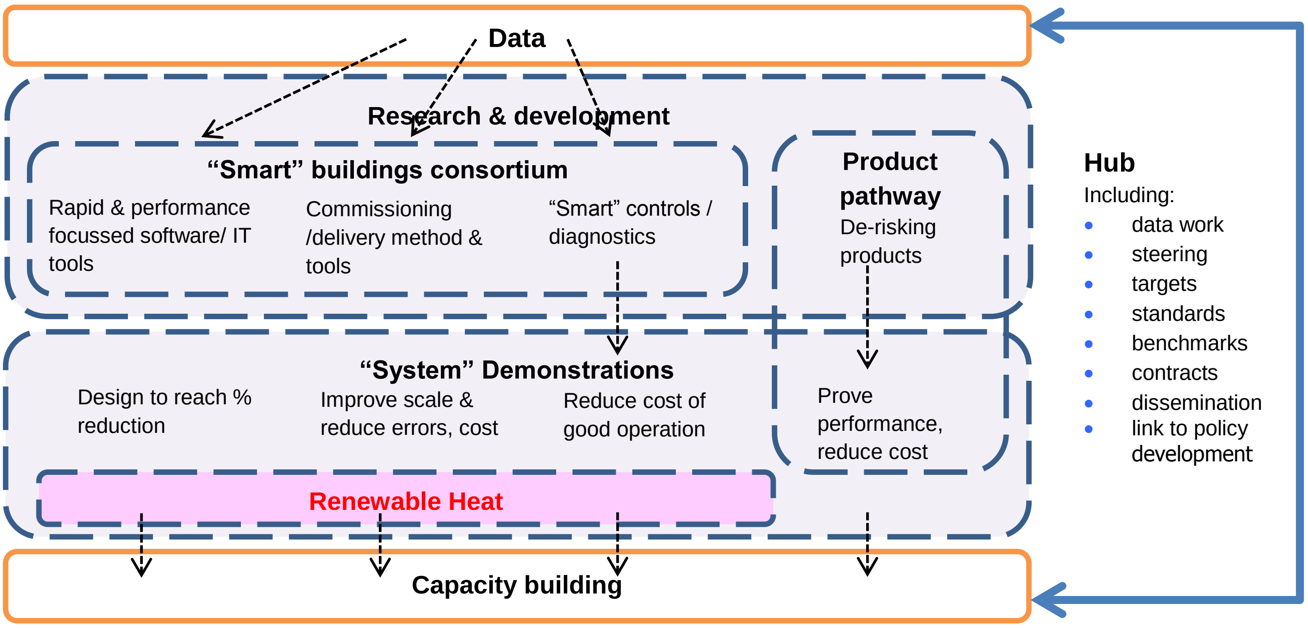
	Sub-area	Value of energy saving (£bn)[28]	Value of business creation (£bn)[29]	UK competitive advantage	Extent of market barrier	Opportunity to rely on someone else	Benefit of UK public sector activity
Pre-construction and design	Modelling and software	3.5 (1.6 – 8.1)	0.7 (0.3 – 1.5)	Medium-high	Critical	No	**High**
	Tools to identify retrofit opportunities				Critical	No	**High**
	Design tools and services for district heating				Moderate	No	**Medium**
Build process	Smart manufacturing processes	4.5 (1.9 – 9.5)	0.2 (0.08 – 0.4)	Low-medium	Minor	In part	**Low**
	Industrialised retrofit techniques				Significant	In part	**Medium**
Building operation	Smart controls and diagnostics	9.2 (4.6 – 23)	0.6 (0.4 – 2)	Medium	Significant	In part	**High**
	Behaviour change				Significant	In part	**High**
Materials and components	Improved fenestration	0.7 (0.3 - 1.3)	0.03 (0.01 – 0.06)	Medium	Moderate	In part	**Low**
	Advanced insulation and thermal materials				Critical	In part	**Medium**
	Passive and low carbon cooling and ventilation technologies				Significant	In part	**Low**

[27] BRE Carbon Trust, Analysis

[28] 2015-2050 cumulative, discounted medium (low-high) deployment.

[29] 2015-2050 cumulative, discounted medium (low-high) deployment.

Chart 8 - Summary schema of public sector support



Potential priorities for public sector innovation support

In the sections above, key innovation needs and market barriers were identified. The analysis points to a number of priorities for public sector investment in innovation. These include both overarching needs and those specific to each innovation area.

Overcoming the various market barriers will require an integrated approach, illustrated in ***Chart 8***. Although each area could be treated in isolation, all areas are interconnected and realising the full benefit of investment will require an integrated approach to solve the numerous market barriers across the entire value chain.

Key overarching needs common across the domestic buildings sector include:

- A sophisticated **national domestic buildings energy performance database.**
- **Systematic gathering** of best practice internationally, including developed case study insights on best practice.
- **Technology and process innovation road-mapping** involving industry and government.
- **Better prioritisation of independent, non-partisan research** into specific innovation areas.
- **Broader research** into what has worked and why.
- Creation and coordination of ways to **encourage uptake**, such as challenges, competitions, and innovative financing schemes.

Though organisations such as the Zero Carbon Hub and the National Refurbishment Centre already play a role in facilitation, a high-level integrated hub for domestic buildings could manage data centrally, set targets, standards and benchmarks, and provide a centralised repository for knowledge across the domestic buildings sector, thus meeting several of the above identified needs.

A detailed assessment of needs, current activities, potential activities and the indicative scale of public sector support is shown in ***Chart 9***.

Underpinning all innovations is a need for more data regarding building performance. There is currently a lack of knowledge surrounding the performance of buildings, hindering improvement. Gathering data on actual building performance is vital and will support efficiency savings in all areas. The BIM task group are developing a unified classification system and data gathering protocol for the operational phase and performance outcomes of built assets. However, data collecting mechanisms and data interpretation remain to be addressed and the new classification system for BIM, Uniclass 2015, relates to the construction of buildings only, not their operation.

There are existing government programmes such as NEED (National Energy Efficiency Data Framework, set up by DECC in 2014 to provide a better understanding of energy use and energy efficiency in Great Britain) which represent progress towards more consistent data collection and interpretation. Further consideration is needed to encourage the synergy of multiple schemes and the setup of a purpose-built database platform.

The Building Data Exchange, hosted by the Digital Catapult, provides a platform that could host the data, case studies, and perhaps also from which the classification standard for the operational phase of buildings could emerge.

Systematic knowledge sharing is needed to create and shorten the feedback loop across the buildings value chain. The benefits of an information dissemination platform are:

- Preventing wasted efforts on "reinventing the wheel".
- Enabling a more integrated approach by allowing information to flow freely across building stages, e.g. design can incorporate feedback from the construction and operation stage, and the product manufacturer can have better insight into what has worked and what could work better.
- Allowing buildings stakeholders to Identify suitable products through sharing of product information such as claimed performance, actual performance, and feasibility to use.

Investment is required in research and development across all technology areas, to develop new software and design tools, smart building operation controls and new products. As the UK is unique in terms of its building stock, usage patterns and climate, investment is also required in adapting innovations to UK conditions and to demonstrate them.

The type of innovation support depends on the technical stage of the innovation need:

- For earlier stage technologies, research and development (R&D), testing and early demonstration for individual components, ranging from new software and commissioning tools, smart building management controls and new products is needed. Mechanisms for support include grants, prizes, and "seed" equity investment.
- For mid-stage technologies, controlled demonstrations of a suite of technologies or complex processes are needed. These demonstrations will involve collaboration between technology/service providers and major contractors/designers or landlords/owner-occupiers, e.g. to achieve innovation in smart manufacturing, industrialised retrofit, smart controls, diagnostics, and user behaviour modifiers. Mechanisms for support include direct grants or grants to convened consortia of end-users of select technology/service providers, similar to the "accelerator" model.
- For late stage technologies, integration of technically but not commercially proven technologies into building projects already planning to do something relatively ambitious e.g. to improve design and observations and measurements on retrofit, or install and "prove" more costly but more effective façade materials.

Retrofit represents significant opportunities in low carbon. Aside from a robust supply chain, innovation in business models and technologies are needed to enable refurbishment at scale. Whole house retrofit modelling is also a gap as this can help to create a long term property development plan. The incremental retrofit plans for privately owned homes that result from such modelling allow owners to progress their retrofit with whatever capital that is available rather needing to invest large amounts up front.

Buildings integration with the macro system

Apart from investigating the buildings system internally, it is also essential to better understand how buildings interact externally with the wider built environment. The roles of buildings need to be explored further. To this end, buildings digitisation is essential, by incorporating big data and IoT (Internet of Things), digitisation will facilitate controllers to communicate with each other and create the buildings performance information feedback loops that are currently missing and which are crucial to driving improved performance. This will enable the integration of buildings with macro infrastructure such as energy systems, with benefits such as precision responses to energy demand and balancing grid peak loading with energy storage.

Non-innovative support

There are also a number of overarching needs that require non-innovative but necessary interventions. These include:

- **Convening fora** to discuss and define new practices that integrate best available buildings technologies with knowledge sharing activities.
- **Development of essential skills** using learning modules developed in partnership with lessons emerging from innovation demonstration programmes. It is important to ensure stakeholders throughout the building value chain e.g. vendors, contractors, but also users understand the design, expected performance, and optimal way to use buildings and are competent in making the right decisions.
- **A knowledge forum** to disseminate benefits of different buildings technologies to designers and developers.
- **Quantification of co-benefits** (e.g. health, safety, and poverty reduction) to raise awareness of the wider benefits of low carbon buildings, increase the feasibility of retrofits, and (within government) encourage cross-departmental actions.
- Identify ways to **reduce compliance costs** and allow regulation to be efficiently enforced.
- **Engage consumers/householders** in a more compelling way, e.g. "your neighbour spends less on their energy bills".

Chart 9 - Potential domestic buildings innovation priorities and support

Technology area	Key needs	Current activities	Future potential activities[30]	Indicative scale of support
Pre-construction and design	• Improve the accuracy and speed **of modelling and software** by better incorporating operational performance data. • Development and demonstration of **modelling tools** that enable designers to better assess and manage uncertainties in buildings' carbon performance. • Develop innovations that allow rapid assessment through **mass surveying tools**, of existing buildings to identify barriers in performance. • To ensure that the design of dwellings can accommodate and **integrate with microgeneration and district heating technologies.** • Identify and improven **ancillary tools** that support decision making, such as utilising **operational profiles** to allow comparative design with typical buildings of similar specification. • Develop and demonstrate **optimisation tools** for multiple variables, e.g. carbon emissions per capita, occupier, or area. • Develop **standardisation and guidelines** for a better pre-construction and design process. • Develop and demonstrate **calculator tools** for quantitative and qualitative information. • Develop whole house **retrofit modelling tools.**	• National Refurbishment Centre • Innovate UK[31] Retrofit for the Future • Innovate UK Building Performance Evaluation programme • English House Condition Survey • *Innovate UK "Buildings, better connected"*	• Prize funding challenge to develop tools for enhancing energy modelling techniques. • Early pre-commercial demonstration programme for modelling tools and techniques. • Establish consortia for retrofit tools. • In-use data collection programme for highly-rated buildings. • Convened consortia including major social landlords and professional bodies to define and demonstrate new practices, combined with knowledge sharing activities.	Millions of pounds
Build process	• Develop & demonstrate proven, cost-effective components and systems for **off-site construction** and installation of building elements. • Develop & demonstrate rapid, cost-effective solutions for **low carbon retrofit** that can be rolled out in a co-ordinated way. • Sharing **skills and knowledge** across multi-disciplinary teams. • Faster and cheapter **testing and monitoring tools** for whole house heat lost test.	• Social housing retrofit (e.g. Innovate UK Retrofit for the Future) • Inovate UK Rethinking the Build Process • Innovate UK Scaling-up Retrofit (2013) • *Insite* conference • DECC Solid Wall Insulation Research Programme • *Innovate UK "Supply chain integration in construction"* • *DECC/Innovate UK "Invest in Innovative Refurbishment"* • *Innovate UK "Digitising the construction sector"*	• Collaboration for evaluation and demonstration of off-site construction and industrial retrofit. • Research and development of standard and community scale retrofit models. • Support development of standard models that will be appropriate for different building and tenure types. • Trial commercial model for community-scale refurbishment. • Better ways to identify retrofit opportunities, calculating market value and devising action plans. • Tools that integrate design across the construction team e.g. taking account of the change in team responsibility as the project proceeds.	Tens of millions of pounds

[30] Activities/investment that happened after 2012 – when the original TINA was published – are in *Italic*.

[31] Formerly the Technology Strategy Board (TSB).

Technology area	Key needs	Current activities	Future potential activities	Indicative scale of support
Building operation	• Timely information from and about household **energy consuming systems** and services. • Research, development and early demonstration of **smart metering and intelligent control systems** that are appropriate to residents. • Demonstration of technologies, promotions and other awareness raising initiatives is needed, which will assist **behavioural change** among building users by allowing them to automate control. • Measures that translate to **"unregulated" energy** use (appliances and plug-in equipment), which is increasing. • Ways of **demonstrating benefits** (financial and non-financial) to buildings occupiers. • Establish **interface protocols** to enable controllers to communicate with each other. • Development of low cost **benchmarking guidance** on operational performance based on building profiles.	• ETI Smart Systems and Heat programme. • Innovate UK/BRE *Energy Pet* project. • Ofgem Low Carbon Networks Fund. • Chartered Institute of Building Services Engineers (CIBSE) Intelligent Buildings Group. • *Innovate UK "User Centered Design".* • *Innovate UK "Future Energy Management for Buildings".* • *Innovate UK/EPSRC "Building whole-life performance".*	• Collaborative research and development for smart controls with a focus on making them easy to use for occupiers. • Incubation programme for methods to encourage behavioural change. • Information dissemination programme. • Data collection programme for highly-rated buildings. • Research to evaluate the effectiveness of innovative systems on influencing householder behaviour.	Millions of pounds
Materials and components	• Demonstration of **advanced insulation and thermal materials**, with some research for materials appropriate for retrofit. • Demonstration of **advanced fenestration**, with some research for glazing materials appropriate for retrofit. • Demonstration of demonstrate alternative technologies such as **retrofit mechanical ventilation heat recovery** (MVHR) systems. • Better understanding of **embodied carbon** and end of life buildings waste control, consider the role of buildings in a circular economy. • Faster and cheaper **certification and standardisation** of low carbon materials and components.	• BRE innovation park. • Tata Centre, Wales. • Sustainable Building Envelope Centre. • The Appplication of Innovative Materials, Products, and Processes to meet the Code for Sustainable Homes Level 4 Energy Performance (AIMC4). • CIBSE Natural Ventilation Group.	• Challenge-based collaborative R&D in early stage fabric technologies aimed at improving performance. • Prize-funding for integration of later-stage technologies into real refurbishments combined with pre-commercial field trials to scale-up. • Field trials considering most efficient rated buildings, to see why they are performing better than average.	Tens of millions of pounds

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