Department for the Economy

Research into the Future of Energy Efficiency Policy in Northern Ireland

Report

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ARUP

Contents

			Page
Executive summary			**3**
1	**Introduction**		**8**
	1.1	The importance of energy efficiency	8
	1.2	Purpose of this report	9
	1.3	Overview of method and structure of this report	9
	1.4	A note on COVID-19	10
2	**Context for energy efficiency in Northern Ireland**		**11**
	2.1	Introduction	11
	2.2	Market failures	11
	2.3	Energy efficiency performance benchmarking	12
	2.4	Synthesis of energy efficiency strategies	15
	2.5	Review of energy efficiency responsibilities at national levels	18
	2.6	The role of local councils	19
	2.7	Minimum energy efficiency standards	22
	2.8	Energy efficiency obligations	25
3	**Stakeholder engagement**		**33**
	3.1	Approach	33
	3.2	Findings	34
4	**Modelling**		**37**
	4.1	Overview of our approach	37
	4.2	Limitations	38
	4.3	The Northern Ireland building stock	39
	4.4	Lever modelling	51
	4.5	Results and findings	59
5	**Analysis**		**76**
	5.1	Roles and responsibilities	76
	5.2	Funding and financing	77
	5.3	Communication and engagement strategy	79
	5.4	Energy efficiency targets	80
	5.5	A one-stop shop and district councils	81
	5.6	Skills requirements	84
6	**Conclusions and recommendations**		**86**
	6.1	Overview	86
	6.2	Lever recommendations	86

6.3 Choices for funding mechanisms 87
6.4 Design and implementation factors 88

References **191**

Appendices

Appendix A : Literature Review

Appendix B : Stakeholder descriptions

Appendix C : Planned or projected growth areas

Appendix D : Building characteristics by tenure and location

Appendix E : GIS outputs

Appendix F : Low and Localised scenario results

Appendix G : Intervention costs

Executive summary

Arup was commissioned by the Department for the Economy to undertake research into energy efficiency policy to inform the development of a new Energy Strategy for Northern Ireland (NI). This report summarises the work undertaken, including the context for energy efficiency in NI, findings of engagement with relevant stakeholders, and modelling of future energy demand based on NI building stock data and applicable policy levers.

Our findings

There are approximately 799,000 domestic (Department for Communities, 2019) and 73,000 non-domestic (Delorme & Neely, 2016) buildings in NI. Building energy efficiency levels across the stock are good but with great room for improvement. Although over 50% of dwellings have some cavity wall and loft insulation and over 85% have double glazing, less than 50% of housing has an Energy Efficiency Rating (EER) band at C or above (NIHE and National Statistics, 2016).

Our benchmarking review of policy today identified four main energy efficiency programmes and policies in NI that provide a total of around £14 per capita in funding. This is less than the policy funding commitments for Scotland and Wales but is higher than funding in Republic of Ireland and England. This per capita analysis was carried out before a number of additional schemes (i.e. Green Homes Grant, Public Sector Decarbonisation Scheme, and Social Housing Decarbonisation Fund) were announced for England in July 2020.

Our modelling of future policies indicates that a dramatic change in policy extent and funding levels is required for NI to put building energy performance in line with the UK's net zero carbon emissions commitment. The modelling indicates that a peak of retrofit measures for up to 30,000 buildings per annum is the minimum necessary to align with the UK's 2030 energy efficiency target. In order to align with 2050 net zero commitments, it is estimated that policies would need to drive an annual peak of retrofits for over 50,000 buildings within the next decade. By comparison, current energy efficiency programmes in NI deliver measures for approximately 16,500 buildings per year, indicating that a doubling or trebling is needed. Deeper levels of retrofit per building are also required, with our modelled High scenario indicating peak annual energy savings that are 14 times higher than the historic annual figures for the current NI programmes.

The High intervention scenario modelled in this research achieves a 55% reduction in energy demand by 2050, and is the only scenario commensurate with projections for energy efficiency that align fully with UK carbon reduction pathways to 2050 (Figure 1).

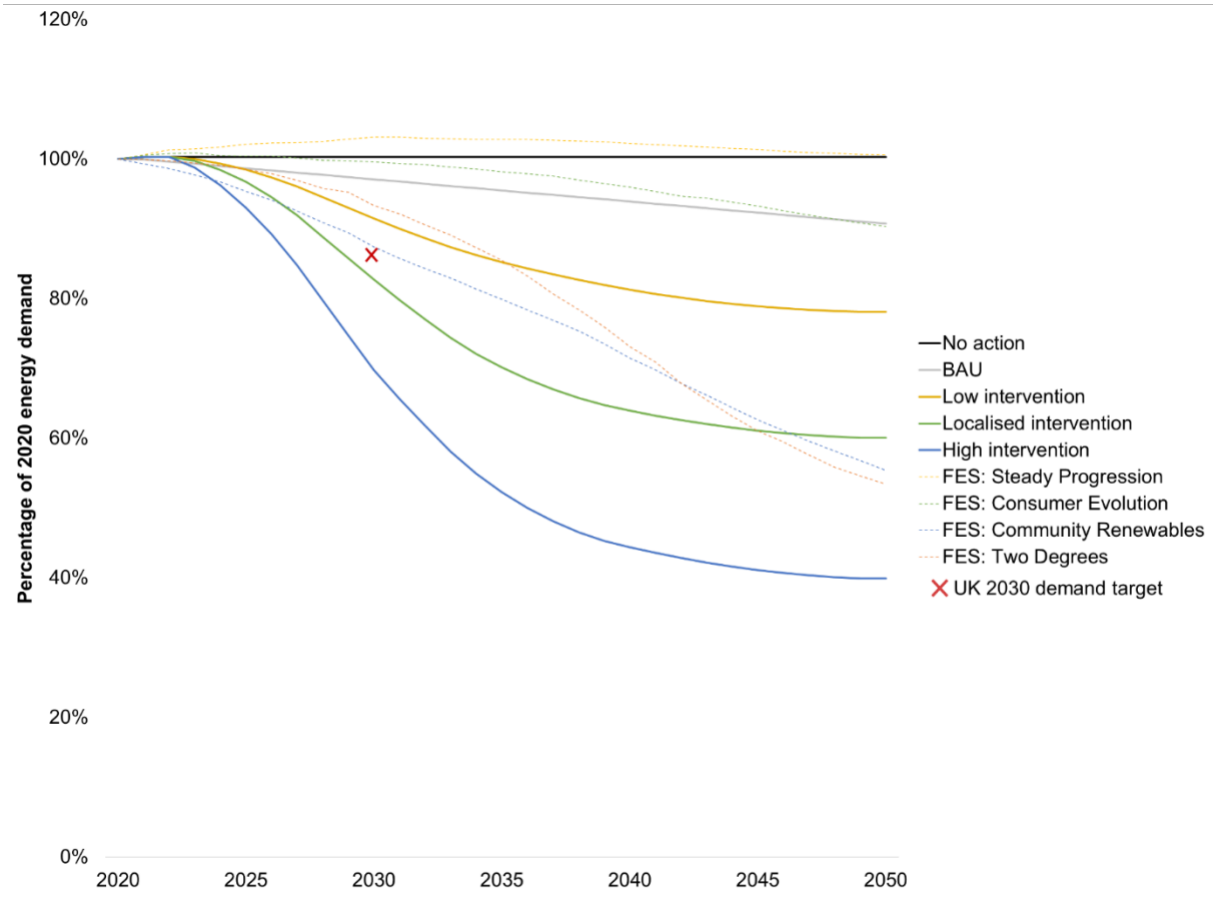


Figure 1: Modelled energy demand trajectories compared against the No Action & BAU scenarios for NI as well as the four National Grid FES 2019 trajectories (National Grid, 2019). Also plotted is the 2030 energy demand reduction target for the UK as specified by the Net Zero technical report (CCC, 2019c).

Recommended approach

Recommendation One

A coordinated portfolio of levers is required that provide long-term support across building tenures. We estimate that the modelled High scenario most closely illustrates the level of ambition required, and includes the following levers:

- **Minimum energy efficiency standards** (MEES) establish a minimum standard of EER band for properties, affecting new tenancies and renewals (see section 2.7). In this study, MEES are modelled to provide a significant proportion of the projected energy savings. This type of lever has already been implemented in England and Wales, and is proposed in Scotland, with increasingly stringent targets to the year 2040. Standards "on paper" would need to be supported by government resources for their **promotion, advice and enforcement**. Targeted technical and financial support through grants and loans could enhance effectiveness, especially where the cost of measures exceeds the exemption threshold.
- Other financial incentives such as such as rates or stamp duty incentives for Able to Pay domestic tenure groups, large enterprises, and public sector.
- Programme delivery through local or national government action to appoint supply chain partners for the rollout of retrofit in all existing building tenures.

- Technical support through advice for target groups encourage the uptake of interventions for all existing building tenures.
- Loans for building energy efficiency improvements for Able to Pay domestic tenure groups, public sector, and large enterprises.
- Grants for building energy efficiency improvements for all Fuel Poor domestic tenure groups and SMEs.

Recommendation Two

With regards to funding mechanisms, an energy efficiency obligation (EEO) scheme presents a possible mechanism for funding and delivery of building upgrades (see section 2.8). Through the evidence collected for this report, there is no clear evidence that an EEO route, or general taxation, is inherently *better*. It is likely to be appropriate to closely link the funding route to the delivery body for programme roll-out (i.e. public sector or energy company). The advantage of an EEO is that it offers a relatively simple and already established outsourced mechanism for funding and delivery of energy efficiency investments. A key disadvantage is that it can risk being a regressive measure which places a relatively greater burden on low income customers. An EEO would need an additional funding or subsidy mechanism to capture the full benefits, or else the measures would be limited to "low hanging fruit" and would fall short of the pathway consistent with a net zero commitment.

We recommend market research with consumers and building users to establish levels of trust in both types of organisation to determine the preferred funding mechanism.

Recommendation Three

We recommend a national '**one-stop shop**' (OSS) designed to promote collaboration of national, regional, and community stakeholders. The OSS acts as an intermediary point of contact between the supply side for energy efficiency services into one offer to the building owners. The renovation process is managed by the OSS organisation which is the single point of contact for the building owner, and suppliers also benefit from this arrangement. An OSS covers the whole or large part of the customer chain from information provision, technical assistance, and provision of financial support, to the monitoring of energy savings. The OSS approach would benefit from a community-based social marketing approach, and monitoring and reporting against net zero targets and social impact co-benefits. A suite of funding models will need to be provided to ensure take-up, and quality assurance monitoring would be required to safeguard the long-term confidence in the scheme. A skilled and coordinated supply chain will be required to deliver the work, supported by technical colleges or in-work training, and mobilised through local pilot schemes.

An OSS designed to provide the following elements, described in section 6.4, is likely to be the most successful. Each component will need careful design and engagement to deliver effectively. A proposed approach is presented in the table overleaf.

Table 1: A proposed approach to energy efficiency in buildings

Element	Outcomes
1. Space for collaboration	A broad network of national, regional, and community stakeholders that collaborate to address the multiple barriers and opportunities by sharing objectives, networks and resources.
2. A successful communication and engagement campaign	Develop a community-based social marketing approach; e.g. using social media influencers, and trusted local partners to deliver key messages.
3. A strategic plan and programme for delivery	Establish a development roadmap based on the outputs of working groups with a 'do now, do soon, do later' structure and 'no regrets' approach taking into consideration the readiness assessment and the inter-relationships between the different elements.
4. Monitoring and reporting targets	A direct link between upgrade targets optimised across the entire building stock and net zero carbon ambitions to drive commitment and collaboration across all stakeholders.
5. An approach to maximise social impact	An approach that measures and maximises the wider social impact benefits of building retrofits in order to galvanise wider support and potential blended finance approaches. Beyond the climate change and energy targets, there are co-benefits to energy efficiency including: • warmer and drier homes in winter lead to physical and mental health benefits which will reduce demand on the NHS and social care; • improved learning, because of reduced school absenteeism from illness and because children learn better in warm homes; • reduced impacts on vulnerable households from increases in energy costs; the creation of a substantial market for local firms supplying energy efficiency products and services; • higher employment and higher incomes; • lower rent arrears for social and private landlords; and • less investment will be needed to generate, store and transmit decarbonised energy. These co-benefits were illustrated by a study by Arup for the Strategic Investment Board (SIB, 2014) which showed that improving the energy efficiency of 60,000 homes in fuel poverty in NI would generate a social return on investment (SROI) of between 4 and 15, depending on assumptions. Another example of co-benefits comes from Scotland. The rollout of the Energy Efficient Scotland Programme is estimated to create a substantial Scottish market and supply chain for energy efficiency services and technologies, with every £100 million spent on energy efficiency improvements in 2018 estimated to support approximately 1,200 full-time equivalent jobs across the Scottish economy (Scottish Government, 2018b).
6. Quality assurance	An approved set of standards and effective delivery and monitoring mechanisms to provide confidence in both the recommendation of interventions and the quality of the work subsequently carried out that is robust enough to support funding mechanisms and simple enough to enable wide-spread adoption in the supply chain and understanding in the community.
7. Provision of technical models to support a targeted roll-out	A solid foundation of technical understanding of the archetype-specific challenges, costs and benefits associated with the 'whole house' plans necessary for net zero ambitions including the individual interventions and the most appropriate logical order for phased, 'no regrets' approaches.

8. Access to funding	A suite of funding models that mean building owners are willing and able to fund and/or participate in building retrofits. This may include an effective blend of grants, personal investments, loans, and 'pay as you save' models.
9. Support for the supply chain	A skilled, coordinated and quality assured supply chain supporting where possible the local economy and which is of the scale required to match credible, significant and stable future demand.
10. Delivering local pilots	A particular criticism of the Green Deal by the National Audit Office (2016) was that its ideas were not tested. Therefore, pilots should be developed for the technical, quality assurance, business and finance models with a focus on the relationship between them and an emphasis on stimulating demand in a way that will mobilise the supply chain.

Recommendation Four

In terms of **overall target**, although NI contributes to the UK energy reduction target, there is currently no energy efficiency target for NI. Establishing an energy efficiency target could be beneficial as it could place the onus on programmes to explicitly target and monitor energy efficiency, and ultimately, could lead to an increased incentive and drive to deliver on energy efficiency. Possible suitable metrics include energy consumption per unit floorspace (e.g. kWh/m^2/yr) or unit of economic output (kWh/£GDP/yr). Of these two, we consider that the rate per unit floorspace is most directly related to the policy purpose under consideration, which is to improve the energy efficiency of buildings. We recommend that further analysis is carried out to determine the historic values and most recent baseline of gross energy building efficiency in NI. This will enable a future target value to be set with a clear understanding of its relation to the country's current position. At a **policy or programme level**, we have found evidence that the setting of clear targets for key actors can assist in uptake of energy efficiency improvements in the housing stock. Targets and obligations should be simple, easy-to-interpret, and with clear eligibility criteria without being overly prescriptive (Rosenow, 2012c). At the **property level**, there is a call to reform monitoring metrics and certification to reflect real-world performance, rather than modelled data (e.g. SAP). Accurate performance testing and reporting must be made widespread, committing developers to the standards they advertise (CCC, 2019b). This approach is being implemented in London under the 'be seen' planning policies of the draft new London Plan (Greater London Authority, 2018). See section 5.4.2 for further information.

Recommendation Five

Building retrofits, especially to higher levels, will require construction workers/installers to develop new **technical skills** both to fit new upgrade measures and to address significant performance gaps. The role of further education is crucial to support vocational training with a curriculum that reflects the broader requirements of building retrofits, as well as to unlock the potential of continuing professional development. A **local accreditation scheme** regularly renewed and linked to locally applicable standards of building retrofit performance could be a useful vehicle. It is recommended that a local/regional pilot scheme is set up to increase understanding of the supply chain skills and the need to establish a local accreditation scheme.

1 Introduction

1.1 The importance of energy efficiency

Energy efficiency is an important component of reducing carbon emissions. This is highlighted by the EU's Energy Efficiency Directive (EED), revised in 2018 to establish a headline EU energy efficiency target for 2030 of at least a 32.5% reduction in energy use compared to projections made for 2030 in 2007 (European Commission, 2020a). The European Green Deal calls for a "renovation wave" of public and private buildings (European Commission, 2019, p. 9) to lower energy bills, reduce energy poverty, and boost the construction sector to support SMEs and local jobs. Further afield, proposals for a 'Green New Deal' in the USA also recognise the importance of energy efficiency in buildings through "upgrading all existing buildings in the United States and building new buildings to achieve maximum energy efficiency" (U.S. House of Representatives, 2019, p. 8)

In June 2019, UK Parliament enshrined into law the net zero target, which commits the UK to reduce emissions by "at least" 100% below 1990 levels in 2050. This will require deep emissions reductions across the economy, with any residual sources offset by removals of CO_2 from the atmosphere (CCC, 2019a). This is a significant increase on the former target under the Climate Change Act 2008 of an 80% reduction by 2050. The Committee on Climate Change (CCC) has stated that NI's contribution to the UK's fifth carbon budget requires emissions reductions of at least 35% against 1990 levels by 2030 and noted that current policies are insufficient to achieve the required reduction (CCC, 2019b). However, it also outlined that there are excellent opportunities to close this gap and potentially reach a 45% reduction by 2030.

For new buildings, revisions to Building Regulations across the UK nations has brought in tighter standards for the efficiency of regulated energy use[1] in buildings. The Government is now consulting on its Future Homes Standard (for England only), which would bring even tighter standards for energy use, carbon emissions, and ventilation performance in homes. The standard is proposed to be brought into effect by 2025 (MHCLG, 2019b).

For existing buildings, the CCC stressed that widespread deployment of energy efficiency measures across the UK's building stock will be a key plank of any credible and cost-effective strategy to meeting net zero. This is exemplified by the UK Government's call for evidence on proposals for a new Business Energy Efficiency Scheme focused on SMEs with options to introduce a periodic auction for energy service companies to deliver energy efficiency measures, or for a business EEO (BEIS & HMT, 2019). However, it is noted that this call for evidence is not directly applicable for NI where energy efficiency is a devolved matter.

The CCC summarise that there has been low uptake of energy efficiency measures, and limited deployment of low-carbon heating options (e.g. heat pumps). The CCC note that the natural gas network in NI is not as extensive as in Great Britain, and some pathways to decarbonise heat that rely on modifying the gas network may be less suitable for NI. However, significant emissions savings could be made by switching conventional oil boilers to heat pumps (CCC, 2019b).

[1] Regulated energy includes the energy associated with the fixed mechanical, heating and electrical plant and equipment in the building and typically excludes plug loads.

Major improvements to the energy efficiency of new and existing buildings is required, and policy to achieve this in NI will largely be delivered through devolved policy.

1.2 Purpose of this report

A new overarching Energy Strategy with a long-term vision towards 2050 is currently being developed by the Department for the Economy (DfE). The DfE plans to issue a draft policy options consultation in March 2021, and a final Energy Strategy by November 2021 (DfE, 2020c). This report summarises research undertaken to inform development of energy efficiency policy, with the focus on energy efficiency in buildings, which will form part of the overarching Energy Strategy.

1.3 Overview of method and structure of this report

Between January and June 2020, Arup undertook research comprising the following elements:

- The context of energy efficiency in NI was established (Section 2), informed by a literature review of policy in NI and other geographies (Appendix A).
- Stakeholder engagement was carried out to uncover views on current barriers to energy efficiency, suggestions for the future in terms of levers and targets, and potential roles and responsibilities (summarised in Section 3).
- Data on NI building stock was analysed (Section 4.1) in order to inform modelling of levers to project energy demand for a range of scenarios (Section 4.4).
- Analysis to develop policy recommendations (Section 5).
- Conclusions and recommendations (Section 6)

The table below provides a quick reference for finding information relating to the stated project objectives.

Table 2: Mapping project objectives to this report

Objective	Section
NI energy efficiency performance, benchmarking against elsewhere in UK and Ireland	2.3
Synthesis of energy efficiency strategies	2.4
Review of energy efficiency responsibilities in other jurisdictions compared to NI	2.5
Benchmark the level of funding and resourcing for energy efficiency policies in NI with elsewhere in the UK and Ireland	2.4
Opportunities for local councils to play a greater role	2.6, 5.5
Profile and analysis of key NI energy efficiency metrics and trends, including the condition and characteristics of the current building stock	4.1
Key market failures that exist in NI in relation to energy efficiency and identify where government intervention should focus	2.2
Coverage and focus of existing energy efficiency schemes in operation in NI, gaps and/or overlap in provision.	2.4
Review the existing, and opportunities for further, deployment of energy efficient measures	4.5.1

Objective	Section
Assessment of future incentives to support energy efficient measures	4.5.1
Opportunities for building standards and regulations, including policies building on the use of EPCs	2.7
Merits of using an EEO	2.8
Policy recommendations	6.1
Forecasts of energy consumption	4.5.3

1.4 A note on COVID-19

This study was commissioned prior to the COVID-19 outbreak. Policy analysis now suggests that a green economic recovery would support both addressing climate change and supporting an economic recovery (for example, from the CCC (2020) or the International Energy Agency (2020)). This has not explicitly been considered as part of this study, but we recommend that further analysis would support more focused and targeted policy-making. Note that as this report was being finalised, the 'summer mini budget' (HM Treasury, 2020) was announced on 8th July 2020 as part of the UK Government's response to stimulate the UK economy following the COVID-19 pandemic. Policies included in this mini-budget that are relevant to energy efficiency are described in Section 2.4.

2 Context for energy efficiency in Northern Ireland

2.1 Introduction

This section presents a synthesis of the context for energy efficiency in NI. This is informed by the literature review (Appendix A) which included a comparison of NI with energy efficiency policy in United Kingdom (UK) as a whole, Republic of Ireland (RoI), Scotland, Wales, Germany, and the Netherlands. This section sets out issues such as market failures, as well as potential opportunities highlighted by the DfE, such as the role of local councils, minimum energy efficiency standards, and EEOs. The purpose is to provide an evidence base for the recommendations being drawn in Section 6.

2.2 Market failures

The market failures relating to energy efficiency are presented in the appendix, Section A3.1.3. All of the market failures are present in NI, however, the ones described below are noteworthy based on the evidence, and therefore these are where government intervention should focus.

- **Landlord/tenant split incentives**. This significantly constrains the uptake of efficiency measures in rented property. This failure results from the common situation whereby a landlord is responsible for meeting the cost of the improvement work, but only receives a benefit where the work increases the rental or re-sale value of the property. The tenant, who is typically responsible for paying the energy bills and would thus see the benefit of the work, is unlikely to be willing to invest in a property they do not own, or may not be permitted to undertake the improvement work. Additionally, tenants may not have the financial capability to invest in making any changes, perhaps evidenced by the fact that private renters have, on average, the highest levels of fuel poverty at 26% of households according to the latest NI House Condition Survey (NIHE, 2018).
  17% of households in NI live in rented accommodation. Whilst the *Northern Ireland Private Tenancies Order 2006* aims to address the barrier of split incentives between landlords and tenants[2], it seems unlikely that this barrier has been completely addressed. Other geographies, including other UK nations, have sought to tackle this market failure through minimum energy efficiency standards (MEES) regulations.
- **Capabilities**. SMEs face various barriers that deter them from adopting energy efficiency measures; they often lack the time and resources to explore energy efficiency options (BEIS & HMT, 2019), and an estimated 99.6% of business in NI are SMEs[3]. In addition, a common comment during stakeholder engagement for this research related to NI firms lacking the required skills, resources, and ability to learn to provide the goods and services required to deliver energy efficiency.
- **Lack of awareness**. A lack of awareness of energy efficiency measures and appreciation of benefits of improved energy efficiency. This can partly result from a lack of trusted information, and so the long-term benefits of improved energy efficiency are often regarded as less certain. Consequently, energy efficiency is undervalued relative to other

[2] The Order states that a tenant must obtain the landlord's consent to carry out alterations to the property, but this consent cannot be unreasonably withheld (DECC, 2014).
[3] 0.4% of total enterprises in Northern Ireland employ over 250 employees (Northern Ireland Statistics and Research Agency (NISRA), 2019).

investment options and not prioritised as it might otherwise be. SMEs, in particular, lack information about where and how energy is used in their businesses (IEA, 2015). In research undertaken in 2018 that included 12 focus groups with a range of householders, it was found that most people were unfamiliar with any energy efficiency provisions available in NI, including Northern Ireland Sustainable Energy Programme (NISEP) and its individually named schemes (Utility Regulator, 2019). Where there was awareness, this tended to be vague. Therefore, evidence points towards a lack of awareness of energy efficiency in NI.

2.3 Energy efficiency performance benchmarking

2.3.1 Domestic buildings

The chart below illustrates the mean domestic energy use for the UK nations and RoI. Figures are presented on a megawatt-hour per year per dwelling basis for each country. It can be seen the NI is estimated to have the highest energy use per dwelling, and England the lowest.

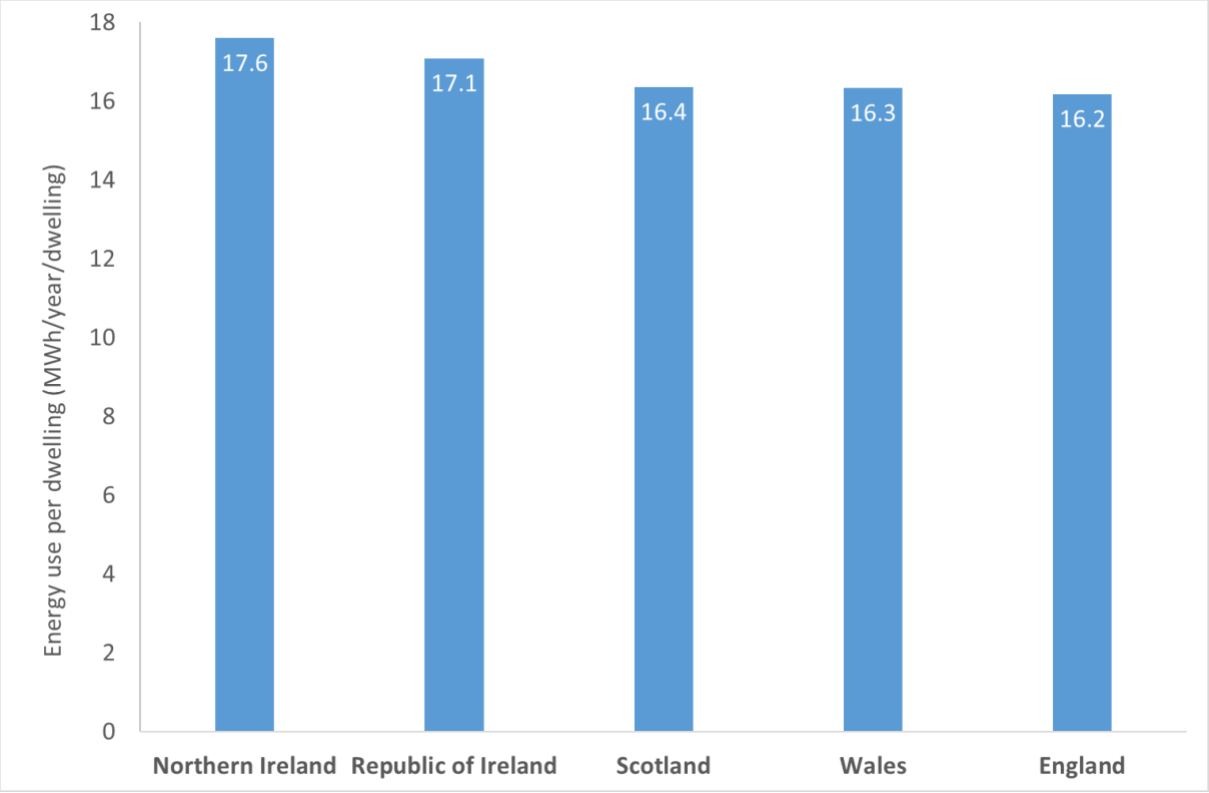


Figure 2: Mean domestic energy use for the UK nations and RoI. Data sources: BEIS (2019a) for UK nations' energy use, MHCLG (2020) for GB nations' dwelling stock numbers, DfC (2018) for NI dwelling stock numbers, Odyssee-Mure (2020) for RoI energy use per dwelling.

The above presents mean domestic energy use, not a measure of energy efficiency, as such. England, Wales and Scotland all had national housing surveys in the field in 2017, and NI's latest survey was in 2016. Whilst the surveys have different sampling criteria and survey instruments, key information which describes the housing stock of the four nations is comparable (BRE Trust, 2020).

Key aspects that may affect energy efficiency are presented in Table 3. The higher energy use per dwelling presented in Figure 2 may be partly explained by the fact that NI has a relatively large average dwelling size and relatively high average number of persons per occupied dwelling.

Conversely, NI has a relatively high proportion of dwellings built post-1990, and newer houses are expected to conform to stricter energy efficiency standards and therefore expected to use less energy per square metre than older houses. NI has the highest levels of insulated cavity walls of the UK nations, which could be expected to contribute to lower levels of energy use. However, the proportion of dwellings with solid walls that have insulation is relatively low for NI, with solid wall dwellings representing approximately 16% of the total housing stock.

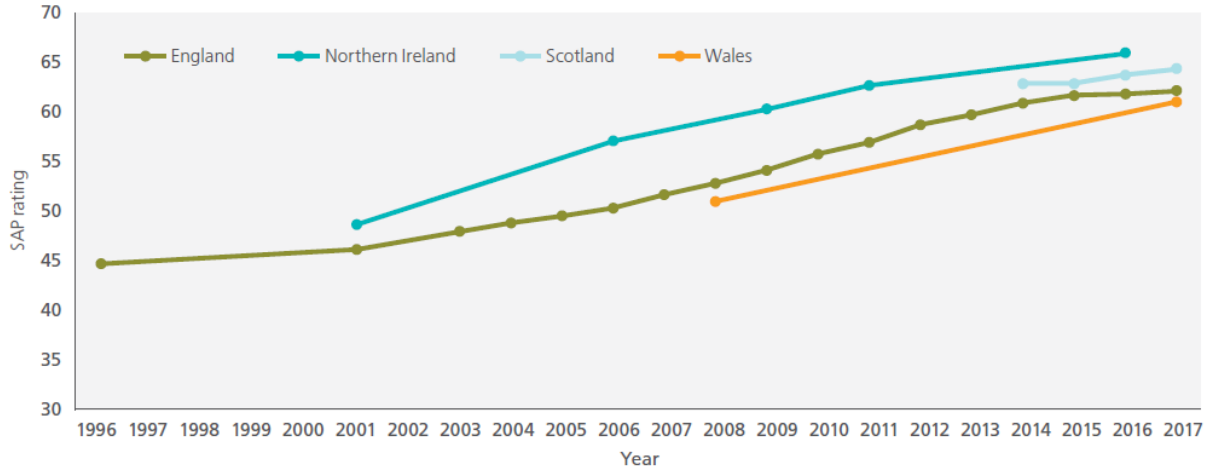
Table 3: Key information comparing UK nations' (BRE Trust, 2020) and RoI's housing stock (CSO, 2016), (SEAI, 2018),. England, Wales, and Scotland data is for 2017. NI data is 2016. RoI data is 2016 except proportion of dwellings built (2011 census). N/A means not available.

	England	NI	RoI	Scotland	Wales
Mean average dwelling size (m^2)	94	105	119	98	102
Mean average number of persons per occupied dwelling	2.43	2.49	2.75	2.20	2.33
Proportion of dwellings built post-1990 (%)	16.8	27.7	41.0	18.4	17.5
Dwellings with cavity walls[4]; proportion that are insulated (%)	68	90	N/A	75	68
Dwellings with solid walls[4]; proportion with insulation (%)	10	9	N/A	18	19

The Standard Assessment Procedure (SAP) may provide a better indicator of energy efficiency. The SAP is adopted by UK Government as the methodology for calculating the energy performance of dwellings. It is based on the energy balance taking into account a range of factors that contribute to energy efficiency, including materials of construction, thermal insulation, air leakage ventilation, heating system controls, and household size and composition (BRE, 2014). The SAP rating is expressed on a scale of 1 to 100, with the higher the number indicating lower running costs. It can be seen from the housing stock estimates in Figure 3 overleaf (BRE Trust, 2020) that NI has the highest average SAP rating for 2016 data compared to other UK nations, and therefore the lowest estimated running costs.

[4] Note that NI figures differ from information published by NIHE on number of insulated cavity walls due to different approaches to categorisation of walls (BRE Trust, 2020, p. 21).

Figure 3: Average housing stock SAP by UK nation (SAP 2012 time series)



2.3.2 Non-domestic buildings

A comparison of non-domestic energy use is presented in Figure 4, with Wales having the highest energy use per building, and NI the lowest. However, the comparison is potentially more complex for non-domestic buildings. The reasons for the differences in energy use between the countries is not clear but could be due to possible differences in building uses and sizes of buildings. Our literature review did not uncover the underlying reasons for the differences.

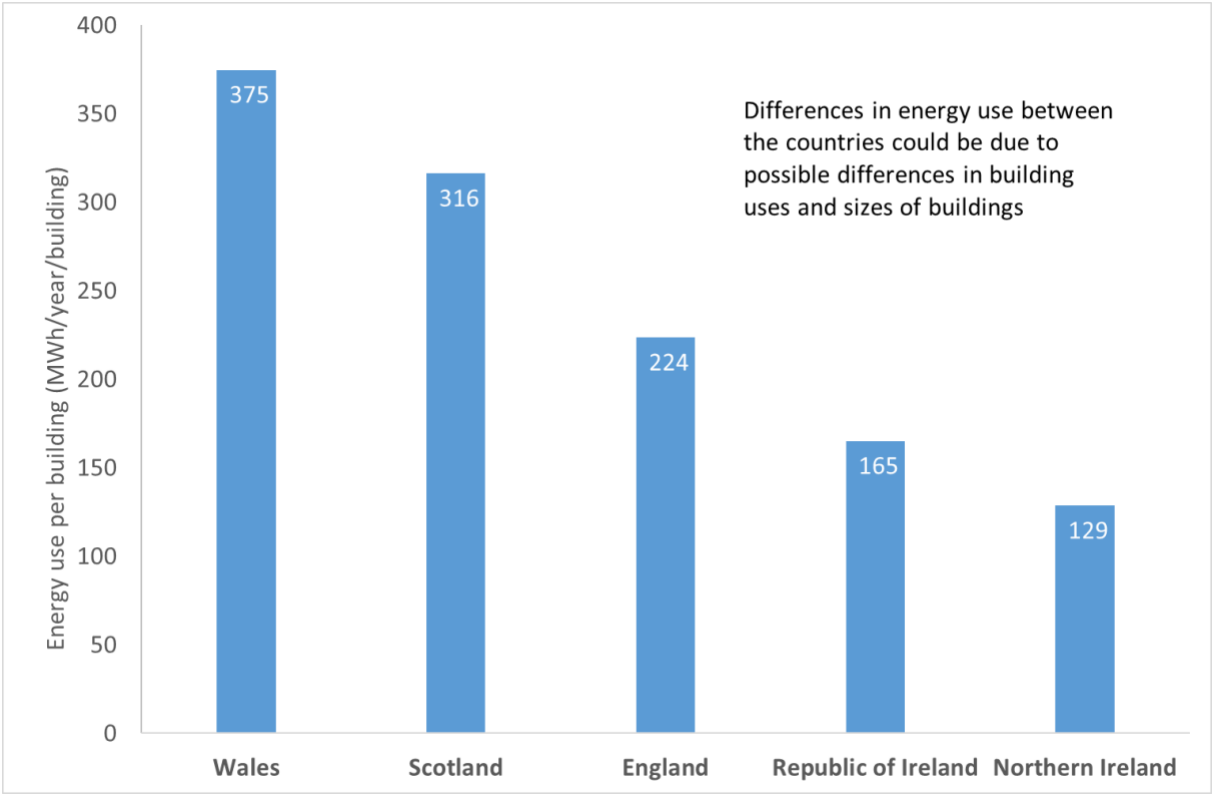


Figure 4: Non-domestic energy use for the UK nations and RoI. Data sources: BEIS (2019a) for UK nations' energy use, SEAI (2015) for RoI's energy use, Delorme & Neely (2016) for NI's number of buildings, Delorme & Hughes (2016) for Scotland's number of buildings, Valuation Office Agency (2014) for England's and Wales's number of buildings.

2.4 Synthesis of energy efficiency strategies

The main ongoing energy efficiency schemes in NI are: the NISEP; Affordable Warmth; Invest NI Resource Efficiency Capital Grant (RECG); and the Boiler Replacement Scheme. NISEP is primarily an energy efficiency scheme whereas Affordable Warmth Scheme is a scheme to alleviate fuel poverty, however, there is some overlap as the schemes offer similar measures. RECG is a grant scheme for businesses, and although focused on resource efficiency (reducing waste or raw materials), it results in energy savings.

Table 4 is informed by the literature review and summarises the types of policy levers that can be applied.

Table 4: Types of policy levers

Policy lever	Description
Funding – grants	The availability of grants for building energy efficiency improvements.
Funding – loans	The availability of loans for building energy efficiency improvements.
Programme delivery	Local or national government action to appoint supply chain partners for the rollout of retrofit in buildings.
Other financial incentives	Financial incentives such as rates or stamp duty incentives.
Standards	Minimum EE standards, EU appliance standards.
Building regulations	Minimum building regulations with regards to regulated energy use.
Planning policy	Policy set by district councils with regards to new developments.
Public reporting	Mandate for certain target groups to display and report building energy performance.
Technical support	Advice for target groups encourage the uptake of interventions.

Whilst it would appear that similar strategies exist, NI lacks two main levers compared to the other European countries: minimum energy efficiency standards (MEES) and a mechanism that places an obligation on energy suppliers to deliver energy savings (an EEO).

The amount of funding provided to policy levers is also relevant. According to Arup's analysis of national Governments' policies for current energy efficiency schemes (as at June 2020), on an absolute basis, England has the highest annual funding, followed by Scotland, Wales, RoI, and NI. However, an analysis of the data on a per capita basis is more meaningful, presented in Figure 5, which is based on schemes currently operating and where data was available.

It can be seen that Scotland has the highest total funding per capita, followed by Wales, NI, RoI, and England. However, the lever modelling carried out as part of this research points towards a significant increase in required funding for NI in order to meet 2050 targets.

It has been suggested that energy efficiency improvements in the UK have been installed in a piecemeal fashion, largely due to the support of UK Government policies, and as a result, the full potential of a system-wide energy package has not been achieved (Liddell, et al., 2016). Germany and Italy are highlighted as countries that do better with a system-wide approach, carrying out energy-saving interventions at the same time (ibid.), but it is not clear from the evidence as to whether there are differences in approach between the UK nations.

Note that the spend by local authorities or governments on their own building stock is not included in the chart. For example, Northern Ireland Housing Executive (NIHE) invested

approximately £20 million in energy efficiency measures within its planned maintenance programme across its own housing stock in 2017/18 (NIHE, 2019a) and £25 million in 2018/19 (NIHE, 2020a).

Also, measures announced on 8th July 2020 as part of the UK Government's 'summer mini budget' (HM Treasury, 2020) have not been included in the chart. There are three proposals relevant to energy efficiency, described below. The following policies are proposed for England.

- The **Green Homes Grant** will provide two-thirds grant to make homes more energy efficient, up to £5,000 per household. For those on the lowest incomes, the scheme will fully fund energy efficiency measures of up to £10,000 per household. In total this could support over 100,000 green jobs. The scheme aims to upgrade over 600,000 homes across England.
- The **Public Sector Decarbonisation Scheme** will invest £1 billion over the next year offering grants to public sector bodies to fund both energy efficiency and low carbon heat upgrades.
- The **Social Housing Decarbonisation Fund** to help social landlords improve the least energy-efficient social rented homes, starting with a £50 million demonstrator project over the next year.

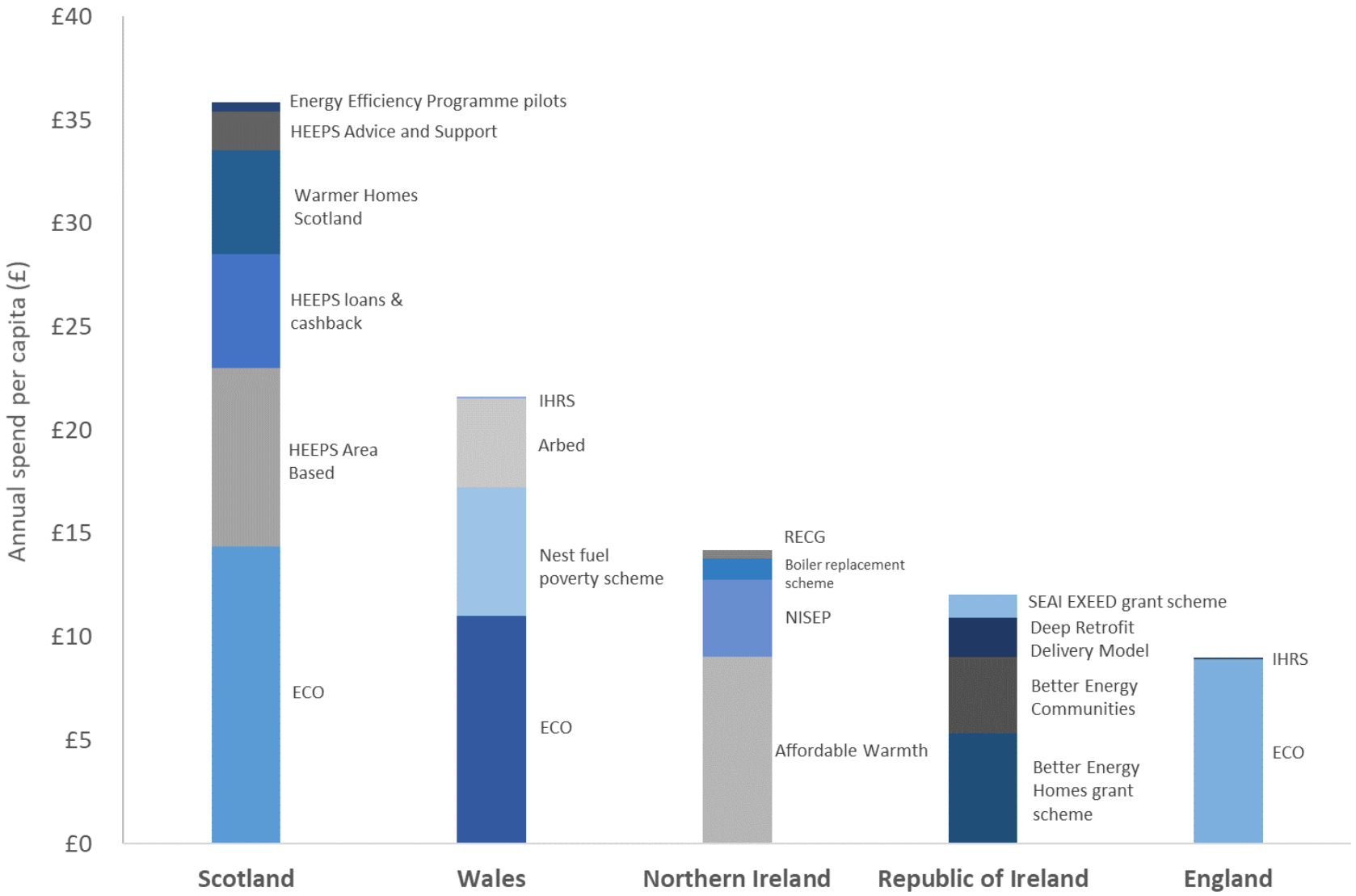


Figure 5: National governments' policies for current energy efficiency schemes (as at June 2020) across UK nations and RoI on a per capita basis. Sources for funding amounts: (House of Commons, 2019), BEIS (2018c) for IHRS apportioned according to populations of England and Wales, (Invest NI, 2020), (Broc, 2017), (SEAI, 2019), (SEAI, 2020a), (AgriLand Media, 2019). ECO funding apportioned according to Table 2.1.5: ECO measures installed, by rurality, by region, up to end December 2017 (BEIS, 2018a). Population estimates from: ONS (2020) and CSO (2017).

2.5 Review of energy efficiency responsibilities at national levels

Under the Northern Ireland Act 1998, energy policy is devolved to NI. Responsibility for ensuring implementation of the EU EED requirements rests with DfE (strategic vision for energy), Department of Finance (for the public sector), Department for Communities (for the domestic sector), Invest NI (for the industrial sector), Department for Infrastructure (transport strategy and sustainable transport), and Northern Ireland Authority for Utility Regulation through promotion of sustainable development in exercising its regulatory duties. The other geographies we considered in the literature review organise their responsibilities as follows:

- For England and Wales, energy efficiency is overseen by the Department for Business, Energy & Industrial Strategy. In addition, the CCC is an independent, statutory body established under the Climate Change Act 2008. The CCC's purpose is to advise the UK and Devolved Administrations on emissions targets and to report to Parliament on progress made in reducing greenhouse gas emissions.
- For Scotland, energy efficiency policy is devolved, as well as heat policy and building standards. However, regulation of energy markets, oil and gas, electricity and gas networks and consumer protection remain reserved to the UK Government.
- For the RoI, energy efficiency is overseen by a single government department, the Department of Communications, Climate Action and Environment (DCCAE). The Department of Housing, Planning, and Local Government publish the Building Regulations Technical Guidance Documents, supporting material and planning guidance. The Sustainable Energy Authority of Ireland (SEAI) helps to bridge the gap between government initiatives and homeowners, tenants, businesses and the public sector. SEAI is responsible for measuring energy savings achieved and for implementing energy efficiency support programmes.
- For the Netherlands, whilst the Ministry of Economic Affairs has responsibility for the EED, other ministries (the Ministry of the Interior and Kingdom Relations and the Ministry of Infrastructure and the Environment) are involved in the implementation of the EED. In addition, the Netherlands Enterprise Agency (RVO.nl) implements several instruments and programmes related to energy efficiency in assignment of the Ministries (CA EED, 2016b).
- For Germany, the EED is overseen by one government department, the Federal Ministry of Economic Affairs and Energy (BMWi). However, a number of other departments are involved. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is involved in the implementation of selected areas of the directive. The Federal Energy Efficiency Center (BfEE) within the Federal Office for Economic Affairs and Export Control (BAFA) is mandated by national law to fulfil reporting and monitoring, as well as communication activities. The BfEE also selects and oversees institutions which conduct energy efficiency research for the ministries. Provisions in the EED concerning the energy market and grids lie within the responsibility of the Bundesnetzagentur (BNetzA). The BAFA, the KfW and different project executing bodies implement energy efficiency measures, initiatives and programs for the ministries (CA EED, 2016a).

The international review indicates that energy efficiency responsibilities tend to be overseen by a single government department. A possible advantage of this approach is that it may

assist in formulating a consistent and coherent approach to energy efficiency. A further advantage is that a centralised approach gives greater visibility and potency to the function and mission of delivering energy efficiency, which is especially important if energy efficiency action is to be increased to the scale needed to contribute to the net zero commitment.

Whilst the overarching energy efficiency programmes tend to be central government-led, we also found that there was distribution of powers and responsibilities to local authorities when it came to the implementation of specific policy measures. The Netherlands, for example, has adopted a district-oriented approach to support building owners make improvements to their homes, with wider support and guidance from central government as required. Locally-based intermediaries can help to build a relationship of trust with households and, when employed to manage the delivery of energy efficiency measures, can simplify the process which helps encourage engagement and uptake of funding schemes. This can be in the form of local authorities or other local delivery partners. Examples of where lessons can be learnt in this respect are the Carbon Emissions Reduction Target in the UK and the Home Energy Efficiency Programmes for Scotland (HEEPS): Area-based scheme in Scotland, which are described in Section A4.1.4 and Section A4.3.2, respectively.

Through our literature review, we looked at the effectiveness of the delivery of energy efficiency policy in different geographies. In reality, the outcomes achieved are made up of a combination of:

- The structure of where the roles and responsibilities lie;
- The capabilities of those teams to deliver them;
- The choice of the policies put in place; and
- The design of these policies.

It is often challenging to distinguish which of these elements have resulted in the delivery of energy savings in different geographies, but it is clear that a combination of all four is important.

Our review also highlights the diversity of governance structures, which places limitations on wholly adopting a model from another country. For NI, we note that government structures are already highly centralised, with few powers and responsibilities devolved to local government bodies. This is most marked in respect of the public estate, where few buildings are owned and managed by district councils. This indicates that a centralised body could fit more naturally with the existing structure, while a distributed structure would require additional upfront investment to ensure each local area had adequate capacity and skills to perform the necessary functions. Our analysis of the implications of this for NI is explored in more detail in section 5.

2.6 The role of local councils

2.6.1 Roles in other jurisdictions and lessons learnt

The role of local councils in energy efficiency delivery varies in other jurisdictions.

In Great Britain, the concept of Local Area Energy Planning is being promoted by a range of partners, including BEIS, Welsh Government and the energy regulator, Ofgem. Local Area

Energy Planning is a means of exploring a range of different future local energy scenarios to achieve deep decarbonisation. The planning process takes a Whole Systems view, accounting for building energy performance, heating technologies, electrification of transport, the capacity of and potential for gas, power and heat networks, local spatial constraints and opportunities. It involves area-specific energy system modelling, embedded in a process of collaborative dialogue between stakeholders and local government (Energy Systems Catapult, 2018).

In RoI, the national government generally defines energy standards for buildings in the framework of the national Building Regulations. In line with many jurisdictions, one of the key opportunities for local authorities is through planning, but this is mainly centred on new build. In RoI some local authorities have introduced building energy standards as part of planning requirements. In Germany, the energy performance of new buildings is checked by the local authorities, who are also in charge of a penalty system. In Wales, local authorities have powers to implement energy efficiency through their local development plans (again, predominantly for new build). In the Netherlands, local authorities have a subsidy scheme to provide a budget to implement energy efficiency and climate policy.

Scotland is perhaps an example of a jurisdiction with a progressive policy for local councils. The emerging 'Local Heat and Energy Efficiency Strategies' (LHEES) framework links long-term targets and national policies to the delivery of energy efficiency and heat decarbonisation at local levels. The policy allows local authorities to prioritise and target work through, for example, supporting owner-occupiers and businesses to install energy efficiency measures or encouraging the development of district heating and other low-carbon heat solutions. Between November 2017 and February 2018, Scottish Government consulted on the introduction of a statutory duty on local authorities to develop LHEES as part of the 'Energy Efficient Scotland' (EES) programme. Scottish Government have since funded two phases of EES pilot projects, with a third currently ongoing (see Appendix Section A4.3.3).

The following lessons learnt have been indicated in the evaluation of the Phase 1 LHEES pilots (Bush, et al., 2018):

- Engaging households who are not in fuel poverty will need more detailed and accurate data, including access to smart meter data.
- Multi-year funding for long term, area-based, programmes is likely to support higher recognition, momentum and uptake of domestic energy efficiency measures by building a positive reputation in communities. Long-term clarity about, and flexibility in, the funding regime for EES would support planning and delivery of more ambitious projects.
- Systematic information and education is needed at the point when households are adjusting to higher energy efficiency and/or new heating systems, to ensure that comfort is combined with energy savings.
- Social survey data showed that non-domestic building occupants attributed value to the works over and above carbon emission reductions and energy savings. In particular, visible improvements were valued highly: e.g. LED lighting improved the atmosphere of a space, and external wall insulation improved the aesthetics of the buildings.
- When considering scaling up to more complex and innovative energy efficiency programmes, essential local authority staff resources and skills were perceived as lacking. Expertise to engage with non-domestic organisations beyond the public sector is one particular gap. Another is the expertise to work with households who will need to borrow or use savings to upgrade property. This extended cross-sector intermediary role for local

authorities on energy use in buildings is unprecedented and will require new types of organisation, networks and procedures.

- At present, non-domestic insulation projects require significant lead-in time to engage with building owners and decision makers in order to develop a common understanding and agreement about what the works would entail and what the results should be. Long term resources are needed to support these activities and to ensure systematic understanding of organisations' circumstances and decision timescales in advance of project planning and delivery.
- There is a need for more differentiated understanding of what energy efficiency investments are affordable for different types and scales of commercial and community organisations. Financial support mechanisms for small businesses and local community organisations need to be reviewed.
- Procurement structures for contractors and materials for the diverse non-domestic sector are likely to need on-going development and review as energy efficiency programmes are established. Opportunities for joint procurement need to be identified to ensure reduced costs, delay and disruption. Establishing channels for sharing best practice in this new area of work will be important.
- In both domestic and non-domestic sectors, pilot projects demonstrated the necessity for review of legal frameworks to enable timely energy efficiency improvements in multi-ownership and multi-purpose buildings.

2.6.2 Roles in Northern Ireland

NI district councils have the following responsibilities relevant to energy efficiency:

- A statutory role for energy efficiency (UK Legislation, 2011); a district council may promote the efficient use of energy in residential accommodation in its district by providing financial assistance or advice, and it may produce action plans to improve energy efficiency in residential accommodation in its district. However, whereas local planning authorities in England and Wales may propose policies imposing reasonable requirements for compliance with energy efficiency standards that exceed the energy requirements of building regulations (UK Legislation, 2008), this is not the case in NI.
- Under the Local Government Act 2014 (UK Legislation, 2014) NI councils have a requirement to produce a Community Plan document. The legislation states that the Community Plan must contribute to the achievement of sustainable development and identify long-term objectives for improving the social, economic, and environmental wellbeing of the district. Councils' community plans, therefore, also consider energy efficiency matters. For example, district councils have a role, along with the NIHE in delivering the Affordable Warmth Scheme on behalf of the Department for Communities (DfC). DfC provides targeted addresses to district councils which then contact those households who have been identified as being most likely to be experiencing fuel poverty and be eligible for the scheme.
- *The Building Regulations (Northern Ireland) Order 1979* (UK Legislation, 1979) assigns a number of duties and responsibilities to district councils which are exercised by the councils' Building Control Officers. These duties include approval of plans for erecting, altering or extending a building, installing services, fittings or works to a building, or to materially change the use of a building. District councils are responsible for the enforcement of the requirements of building regulations within their council boundaries.

As part of their enforcement duties, building control officers will carry out a number of site inspections to ensure that the work complies with the requirements of Building Regulations. They may also serve a contravention notice where they discover work that does not comply with the regulations.

However, district councils have limited responsibility for housing as they do not own housing stock; social housing is held by the NIHE and housing associations. Therefore, it is unlikely that the district councils have experience of implementing energy efficiency in the social housing stock. In addition, district councils have only recently been given planning powers, following local government reform in 2015. Therefore, district councils are in relatively early stages of developing local plans, and planners may have limited experience of construction of new buildings and may need to rely on external resources for a period of time.

Drawing on the foregoing review and the NI context, several opportunities could be considered for NI councils to play a greater role in energy efficiency policies and programmes. The main opportunities are listed below:

- Information campaigns and raising awareness: energy efficiency initiatives could be coupled with other local council information campaigns. This would need to be well managed to support clear and concise messaging.
- Technical support and advice through a local one-stop shop: A local service could include a drop-in advice centre and site visits by local experts.
- Enforcement of policies: inspections and monitoring of compliance with changes in policy, such as landlord minimum energy efficiency standards.
- Delivery of an investment programme: this role could be limited to the few public buildings owned by councils or expanded through local delivery for third-party owned buildings.

Noting the foregoing review, effective performance of these roles would depend on adequate resourcing and skills within the district councils and a national support structure to give guidance and provide an effective policy framework. In chapter 5 we return to this question to consider some of the implications of greater local roles, including skills and funding.

2.7 Minimum energy efficiency standards

Mandatory minimum building energy efficiency standards (MEES) are an approach to driving energy efficiency investment in tenanted building stock. This section provides a brief review of evidence of experience of MEES to date and their potential to be applied in NI.

MEES regulations establish a minimum standard of EER band for properties, used for Energy Performance Certificates (EPCs), required for new tenancies and renewals. An EER rating of A defines a highly energy efficient property and a rating of G defines the least energy efficient properties. EPCs also provide a set of recommendations on how to improve the energy efficiency of the property and potential EER that could be achieved if these recommendations were implemented.

Whilst not currently in legislation, the DfC consultation stated that the department proposes to introduce legislation around EERs “similar to that in England” (DfC, 2017, p. 48) for the private rental sector.

The current legislation in England and Wales is that landlords are obliged to improve ratings to an 'E' or better, unless this cannot be done for £3,500 or less, in which case all improvements which can be made up to that amount need to be made. However, one of the aims of the UK's Clean Growth Strategy (BEIS, 2017) is to get as many homes as possible to EER of C by 2035, where practical, cost-effective and affordable, and for non-domestic buildings, the UK Government's preferred target is that landlords in England and Wales ensure their properties achieve EER of B by 2030, provided the action required is deemed cost effective by meeting a seven-year payback test (BEIS, 2019b).

The application of MEES in England and Wales appears to be an example of a policy lever where the cost threshold (£3,500 or less) may not allow the government to achieve their ambition. It is an example of an approach that reflects the private economic business case, and does not reflect the wider social benefits to energy efficiency including:

- Warmer and drier homes in winter lead to physical and mental health benefits which will reduce demand on the NHS and social care;
- Improved learning, because of reduced school absenteeism from illness and because children learn better in warm homes;
- Reduced impacts on vulnerable households from increases in energy costs;
- The creation of a substantial market for local firms supplying energy efficiency products and services;
- Higher employment and higher incomes; lower rent arrears for social and private landlords; and
- Less investment will be needed to generate, store and transmit decarbonised energy.

These co-benefits were illustrated in a study by Arup for the Strategic Investment Board (SIB, 2014) which showed that improving the energy efficiency of 60,000 homes in fuel poverty in NI would generate a social return on investment (SROI) ratio of between 4 and 15, depending on assumptions. This means that for every £1 spent, between £4 and £15 of social value would be delivered.

Table 5 presents proposed or implemented MEES legislation in different jurisdictions, including those referred to above.

Table 5: Proposed or implemented MEES legislation in different jurisdictions, referring to EERs

Region	Private Rented	Owner occupied	Social rented	Fuel poor households	All homes	Non-domestic
Scotland: proposed (Scottish Government, 2018b)	E by Mar 2022 D by Mar 2025 C by 2030	*Encourage* C by 2040 Consultation: C by 2024 (Housing and Social Justice Directorate, 2019)	*Maximise* B by 2032	C by 2030 B by 2040	C by 2040	Proposals by 2020 and introduce regulation by 2021
England and Wales: legislation	E by Mar 2020					E by Mar 2023 Consultation: B by 2030[5] (BEIS, 2019b)

[5] Provided the action required is deemed cost effective by meeting a seven-year payback test.

Region	Private Rented	Owner occupied	Social rented	Fuel poor households	All homes	Non-domestic
Wales: accepted in principle by Welsh Government[6]	A by 2030		A by 2030		A by 2050	
NI: consultation	"similar to that in England" (DfC, 2017, p. 48) (see 'England and Wales' row above)					
UK target: Clean Growth Strategy (BEIS, 2017)	C by 2030			C by 2030	C by 2035	
the Netherlands: legislation						Office buildings: C by Dec 2022 A by Dec 2029

There are a number of identified challenges for implementing MEES:

- Building owners need to have the capability to act, to be able to afford the energy efficiency measures, in addition to the motivation and the opportunity to implement the measures.
- The preceding point leads to the question of the action taken if building owners do not achieve the required EERs by the required date. Local authorities' budgets are strained and there is concern that there is weak enforcement of the MEES regulations (BEIS Select Committee, 2019). It was found that enforcement action by local authorities is limited (RSM, 2019). Some local authorities are developing systems and looking to enforce the regulations within the next year. Others are yet to undertake any work at all around enforcing the MEES. The ineffectiveness of the exemption criteria for the England and Wales legislation (prior to April 2019) was a key barrier to enforcement, along with a lack of resourcing for this activity within local authorities. Local authorities also have other legislation they can use[7] in order to improve standards in the private rented sector (PRS), and were more familiar with this. It was widely felt that it will be easier to enforce the MEES after April 2020 when the standards apply to existing tenants too (as long as the property has an EPC). However, the practical challenges in identifying non-compliant properties, contacting landlords, and resourcing the activity make it difficult for local authorities to enforce the MEES efficiently.
- The EPC dataset has several limitations. A domestic property is only required to obtain an EPC when it is built, rented or sold, and each EPC certificate is valid for 10 years. Therefore, many properties do not have an EPC and, even where an EPC is available, it may be several years out of date, or no longer valid, and not account for more recent retrofit activities (or degradation) within the property.

[6] The recommendations of the Decarbonising existing homes in Wales report (Decarbonisation of Homes in Wales Advisory Group, 2019) were accepted in principle by the Welsh Minister for Housing and Local Government (Welsh Hosuing Quarterly, 2019)
[7] The Housing Health and Safety Rating System (England) Regulations 2005

- Furthermore, the methodologies used may not always be perfect, with studies finding large discrepancies between modelled and actual energy performance of dwellings in particular (Kelly, et al., 2012). The generalised assumptions used in the modelling process and limited property-specific information required have been criticised, so actual performance must be treated with caution. However, the same factors should apply consistently so the methodologies should provide a reasonable basis for relative performance comparison between buildings.
- Currently, EPC unique property identifiers cannot be linked to other datasets. Although EPC data include addresses, these are not recorded in a standard format, which reduces the success of matching data to other data using addresses, particularly for non-domestic properties which more commonly have inconsistent building names and numbers recorded.

2.8 Energy efficiency obligations

2.8.1 Overview

The basic concept of an EEO is that government imposes an energy savings target on large energy suppliers (gas and electricity) that has to be achieved for customers, which may relate to energy consumption or carbon emissions. Suppliers pass costs of EEOs to their customers via energy bills, and customers can make contributions to some of the measures as well. There are various routes that energy suppliers use (Rosenow, 2012a):

- Firstly, energy suppliers contract installers of energy saving measures (for example cavity wall insulation) that carry out the work in homes according to a defined standard and with a certain benchmark for energy and / or carbon savings.
- Secondly, energy suppliers may subsidise energy efficient products (for example insulation material) sold via retailers.
- Thirdly, energy suppliers deliver their obligation through work with managing agents, Local Authorities, supermarkets and other retailers which in turn subcontract installers and manage the delivery process.
- Finally, energy companies may choose to work with the home occupants directly. For example, compact fluorescent lamps (CFLs) were provided at no cost to occupants. More recently, energy companies, such as British Gas, have set up their own insulation businesses to deliver their obligation.

2.8.2 EEOs in Great Britain

Great Britain was the first region in Europe to introduce an EEO scheme. The following provides a brief history of EEO schemes in Great Britain.

- In 1994, the **Energy Efficiency Standards of Performance (EESoP**) was introduced and ran until 2002. Energy suppliers were set targets in 1994, 1998 and 2000 and successfully implemented their energy efficiency programmes throughout the course of the schemes to achieve energy efficiency savings (Ofgem and EST, 2003). EESoP suppliers were required to focus expenditure on disadvantaged customers. Suppliers met their targets by setting up schemes to deliver energy efficiency measures, with the main types being insulation, lighting, heating and appliances. Insulation was the most common

measure delivered by suppliers, as it provides the greatest benefit in terms of saving customers money off their fuel bills as well as improving their comfort. EESoP ran in three phases, with analysis by the National Audit Office in 1998 showing that the overall net financial benefit of the EESoP 1 programme was £250 million.
Initially the programme required suppliers to spend a fixed amount of money and meet an energy efficiency target. As competition was introduced into the supply market, the focus of the target became much more on the outcome, the energy saving, rather than the inputs, the expenditure. As a consequence of putting the onus on the supplier to determine the amount spent, the EESoP programmes developed into a market mechanism that delivers energy savings through cost-effective energy efficiency measures.

- The **Energy Efficiency Commitment (EEC)** was introduced in 2002 to replace the EESoP programme, and ran until 2008. The EEC aimed to curb carbon emissions by 0.4 MtC per annum, equivalent to around a 1% reduction in carbon emissions from domestic sources.
- EEC was renamed in 2008 to the **Carbon Emissions Reduction Target (CERT)** that ran until 2012. Energy suppliers achieved savings of 297 Mt CO_2, surpassing the target of 293 Mt CO_2 (OFGEM, 2020).

  The **Community Energy Saving Programme (CESP)** ran from 2009 to 2012 and was designed to promote a 'whole house' approach and to treat as many properties as possible in defined geographical areas selected using the Income Domain of the Indices of Multiple Deprivation (IMD). An overall carbon emissions reduction target of 19 Mt CO_2 was set, with 16 Mt CO_2 achieved.
- The current EEO scheme in Great Britain, the **Energy Company Obligation (ECO)**, was established in 2013. ECO provides funding to improve energy efficiency in difficult to treat housing and the homes of 'those most in need'. It originally ran alongside the Green Deal (now ended) which provided loans for energy saving improvements. Under ECO1 suppliers were required to achieve an overall savings target totalling 18 Mt CO_2, with 28 Mt CO_2 achieved (OFGEM, 2020).
- ECO has been deemed a success and the UK Government is now exploring whether to expand it to place obligations on parties to deliver a set amount of energy savings each year to SMEs. Indeed, Great Britain is relatively unusual in Europe in having an EEO that applies to domestic premises only, as most international examples cover both domestic and business premises. Schemes put an obligation on energy suppliers (Great Britain, Ireland, France, Spain, Slovenia, Lithuania, Austria, Poland and Luxembourg) or network operators (Denmark and Italy).

It difficult to compare energy saving targets of the preceding schemes on a like-for-like basis. However, it has been estimated that there has been an eightyfold increase in the targets from 1994-1998 to 2008-2012 (Rosenow, 2012a). The current scheme, ECO, is the principal policy to deliver energy savings in the housing stock in Great Britain, particularly in England, and makes a significant contribution to the funding provision for energy efficiency schemes in Scotland and Wales (see Figure 5 earlier in this report).

2.8.3 Pros and cons of EEOs

Table 6 presents pros and cons of EEOs. Another aspect, not covered in the table, is that experience shows that relying on an EEO as the only instrument to deliver energy efficiency measures presents risks. When political support for levy-funded energy efficiency policy

drops, this could have significant repercussions for the sustainability of the energy efficiency market. Using an EEO as a single instrument also does not exploit the potential synergies with other, complementary measures and a policy mix has been shown to be more effective than relying on single instruments. Standards and norms[8], energy-labelling schemes, and information measures[9] have a reinforcing impact on all other policy types, including EEOs (Rosenow, et al., 2016).

Table 6: Pros and cons of EEO schemes

Pros	Cons
• Well-designed EEO schemes can deliver significant, cost-effective energy savings over many years (Bertoldi, et al., 2010). The evidence base for the social and economic value of EEO schemes is strong and growing (e.g. Rosenow & Bayer (2016)) • EEOs guarantee a steady stream of funding to support implementation of EE measures, independent of changes to government budgets. • Obligated parties (energy companies) are incentivised by competition to deliver obligations using cost-effective and innovative solutions. • An EEO scheme can be tailored to meet social objectives around vulnerable customers, for example by providing that a certain percentage of the energy savings must be achieved within such a group. • Obligated parties who do not fulfil their obligation can be penalised for non-delivery.	• The performance of schemes is determined by the details of policy design, implementation, governance and market structure and conditions (Eyre et al. 2009; Mundaca and Neij 2009). • Potential energy company resistance to delivering this aspect of government energy policy. Energy companies can have internal reasons for opposing EEOs (too burdensome, not their core business etc.), which they may present as protecting their customers from rising prices due to unnecessary government policy (Fawcett, et al., 2019). • Potential public and political resistance to energy price rises that result from an EEO. To mitigate this, support should be sought from trusted actors and interest groups (e.g. consumer groups, environmental, and social NGOs) (Fawcett, et al., 2019).

2.8.4 Potential EEO in Northern Ireland

Through the EED[10], EU Member States have been encouraged to introduce EEOs, and in 2017 there were 15 EU EEOs in existence, compared with just six prior to the introduction of the 2012 EED (Fawcett, et al., 2019). EEO schemes are a key policy tool for the EU. Analysis of Member States' reports shows they are expected to deliver 34% of EED savings which is the largest contribution of any policy instrument. Other savings will come from financing schemes or grants (19%), and taxes (14%), regulation/ voluntary agreements (11%), standards and norms (9%) with smaller contributions from training, national energy efficiency funds, energy labels and any other policy measures (Forster, et al., 2016).

[8] These aim at improving the energy efficiency of products and services.
[9] Provision of advice, billing feedback, and smart metering.
[10] The EED set a target of saving 20% energy use by 2020, compared to business-as-usual projections made in 2007 for the year 2020. In 2018, it was agreed to update the policy framework with an energy efficiency target for 2030 of at least 32.5%. This target, to be achieved collectively across the EU, is set relative to the 2007 modelling projections for 2030.

The EED is flexible in that it allows Member States to choose between an EEO (which could be placed on energy suppliers, distributors or both and which could target particular sectors) and Alternative Measures, to deliver the target. As presented above, Great Britain has an EEO, known as ECO, which delivers energy efficiency savings as required by the EED. ECO is a statutory obligation on electricity and gas suppliers, and 100% of the funding goes to vulnerable and low-income homes, with at least 15% targeted to rural areas.

Currently NISEP is the only NI scheme contributing to this UK-wide energy efficiency target. NISEP was previously set to end in 2016, to be replaced by a new EEO – the Department of Enterprise, Trade and Investment (DETI)[11] published an intention in its Energy Bill policy consultation (DETI, 2012) to explore the introduction of an EEO that would potentially replace the NISEP. The EEO would aim to establish an obligation targeted at the fuel poor, providing access to energy efficiency measures for at least 50,000 low income households, through a 4-year campaign (NEA, 2015). The DETI consultation asked consultees if NISEP should continue in its present form until a new measure could be agreed upon. The majority of responses to the consultation felt that the NISEP should continue in order to ensure continuity in energy efficiency provision (Uregni, 2014). The Utility Regulator agreed to keep the NISEP open until the earlier of March 2016 or the introduction of alternative energy efficiency provision.

Due to the large number of small energy suppliers, particularly for heating oil, in NI, the following specific aspects or issues were identified (DETI, 2012):

- It would be difficult to place an obligation on very small suppliers: in particular the coal and heating oil sectors, which are also unregulated.
- An overly onerous or badly designed supplier obligation could be seen as a disincentive to new energy suppliers entering energy markets. This can be mitigated by excluding small suppliers (defined by annual energy supplied or turnover) from the scheme. However, in turn, this can result in a differential price advantage accruing to smaller suppliers, and a large number of energy suppliers in NI may not be obligated and this would reduce the amount of energy savings that could be achieved.
- If a large proportion of non-networked suppliers (such as oil, coal or renewable heat) were exempted, then the greater proportion of the burden would inevitably fall on the networked natural gas and electricity industries. This may disadvantage customers who rely on electricity and gas for their heating as they would bear the burden of additional costs, while those customers who rely on coal and oil would not. This could create a competitive advantage for the more heavily polluting coal and oil as compared to gas.
- A potential mitigation to the above is to place the burden on the oil importers, as there are only a few large companies involved in bringing oil into NI. These larger companies would perhaps be better able to cope with the additional regulatory burden. However, customers' direct relationship is with energy suppliers, so distributors and importers would not accrue relationship benefits in the same way.

2.8.5 EnergyWise scheme

In May 2016, the Utility Regulator and the DfE issued a joint consultation on the EnergyWise scheme, proposed to be a replacement for NISEP (DfE, 2016). Under the proposed scheme, DfE would provide assistance primarily in the form of grants and/or other funding to eligible

[11] Renamed Department for the Economy in 2016.

electricity consumers to install energy efficiency measures. Under the proposals, only the domestic sector would benefit from EnergyWise grant support.

In contrast to an EEO scheme, where the obligation is on the energy suppliers, the EnergyWise scheme included proposals for recovering funding from electricity customers. This was proposed to be levied directly from electricity bills through the DUoS charge administered by Northern Ireland Electricity Networks (NIEN). DfE considered that the proposed funding route had a number of potential benefits over an EEO on suppliers and/or distributors (DfE, 2016):

- No requirement for detailed primary legislation.
- Economies of scale (presumably due to the levy being charged by a single actor, rather than multiple energy suppliers).
- Better opportunities for coordinated promotion and provision of information to consumers regarding the sources of energy efficiency help available.
- Reduced consumer confusion, which could occur in the event that a large number of energy companies began to offer different levels of help and advice.
- An opportunity to introduce one simple energy efficiency advice telephone line to provide consumers with advice on all the energy efficiency help available.
- Administratively easier to ensure quality standards are maintained, best available energy efficiency measures are installed, and energy efficiency achieved is accurately counted with a centralised scheme.
- An opportunity to seek sources of funding from a number of places and use it to deliver energy efficiency in a coordinated way.

However, it is noted that the EnergyWise proposals did not overcome the potential disadvantage identified by the Energy Bill policy consultation (DETI, 2012). Under the EnergyWise proposals, the levy burden would fall on electricity prices, which may create a competitive advantage for the more heavily polluting coal and heating oil.

Whilst consultation responses pointed towards agreement that a centralised approach to energy efficiency delivery would maximise the impact of funding (The Consumer Council, 2016), (Fermanagh and Omagh District Council, 2016), more detailed EnergyWise proposals were said to be required. This included a view that, without modification, the scheme would not cater well for those in fuel poverty (Northern Ireland Fuel Poverty Coalition, 2016), (National Audit Office, 2016), or commercial organisations (Fermanagh and Omagh District Council, 2016), (Manufacturing NI, 2016).

The NISEP scheme has been extended to 2024, and whilst an EEO has not been implemented to date, it remains one of a number of policy options that will be considered by the DfE during the development of the new Energy Strategy.

2.8.6 Potential routemap to bringing in an EEO

As noted in the preceding section, under the EnergyWise scheme proposed in 2016, the levy burden would fall on electricity prices, leading to a possible competitive advantage for coal and heating oil. Therefore, it is worth highlighting that in the RoI, the Energy Efficiency Obligation Scheme (EEOS) places obligations on energy suppliers and distributors of all energy types (including electricity, gas, and solid fuel) to deliver energy savings to both

domestic and non-domestic sectors. The scheme, which started in 2014, will run until at least 2020 and is administered by the SEAI.

Under the RoI's EEOS, companies who sell large amounts of energy are known as obligated parties. Targets are set, based on their annual sales volume and expressed as a percentage of the total sales volume of all obligated parties. Obligated parties can choose to achieve energy savings independently or through partnerships with service providers in the market. The scheme permits the exchange of validated savings between obligated parties in certain circumstances. Obligated parties can buy out up to a maximum of 30% of their total cumulative target, whether or not they have achieved their minimum cumulative target. For any portion of the minimum annual target not achieved, exchanged or bought out, a penalty is imposed.

The rest of this section describes considerations for a potential routemap for the introduction of an EEO for NI, should it be desired.

Figure 6 shows the length of past consultation processes for Great Britain EEO schemes, the release dates of any guidance, and the dates when secondary legislation came into force. The following observations can be made:

- **Timing of consultation**. Before the start of obligations, consultations on government's proposals generally closed five to eight months before the start date. From the suppliers' perspective, early consultation and decision helps them to set out a business plan and make sure delivery starts early. It also allows for problematic issues to be discussed with government and the utility regulator before the scheme begins, preventing delays later on.
- The **length of the consultation** periods has increased over time, but consultations conducted by the regulator typically lasted one to two months, whereas consultations by the government took two to four months.
- **Supplier guidance**. Previous UK Government guidance, now archived, recommends releasing guidance "at least twelve weeks before a regulation comes into effect" (BIS, 2009, p. 6). However, this was not always done for the GB EEO schemes. Releasing guidance late has negative impacts on delivery, since in order to make sure the target is met, suppliers start carrying out projects from the start of an obligation period. If the exact requirements are unknown there is the risk that projects do not get approval or additional resubmissions are required by the regulator adding extra costs for both the obligated party and regulator as well as impacting on customers' bills.
  However, the EnergyWise funding route proposed for NI potentially mitigates this risk since the obligation would not be on energy suppliers.

Beyond the initial routemap for bringing in an EEO, there are several factors that the successful schemes have in common (Fawcett, et al., 2019), and should be taken into consideration for the design and ongoing operation of an EEO:

- Start with modest levels of savings targets and increase ambition level of target savings over time. For example, in the UK, significant savings targets were only set after the first 8 years of the scheme. In France, the first 3 years of the EEO (2006–2009) were treated as a trial period with low savings targets, so that obligated parties could acclimatise to the system and build relationships with the various stakeholders needed to deliver measures. The scheme was redesigned after experience in the first phase. There was a similar pattern of gradual introduction, learning and redesign in Italy and Denmark.
  The initial learning period of a scheme could be shortened by building on existing

experience of a voluntary scheme for obligated parties, or adopting (and adapting) a successful EEO design from another country.

- Learn from early phases and redesigning the EEO scheme to be more efficient and effective. EEOs are unlikely to meet deeper savings targets over multi-year periods without the discipline of programme reviews, including ex-post evaluation and policy redesign, leading to innovations in implementation.
- Consistently evaluate the performance of the EEO scheme and have an independent authority to check them and be ready to implement sanctions if savings are not delivered.
- Have effective sanctions in case of non-compliance.
- Have transparent methods of calculating savings.

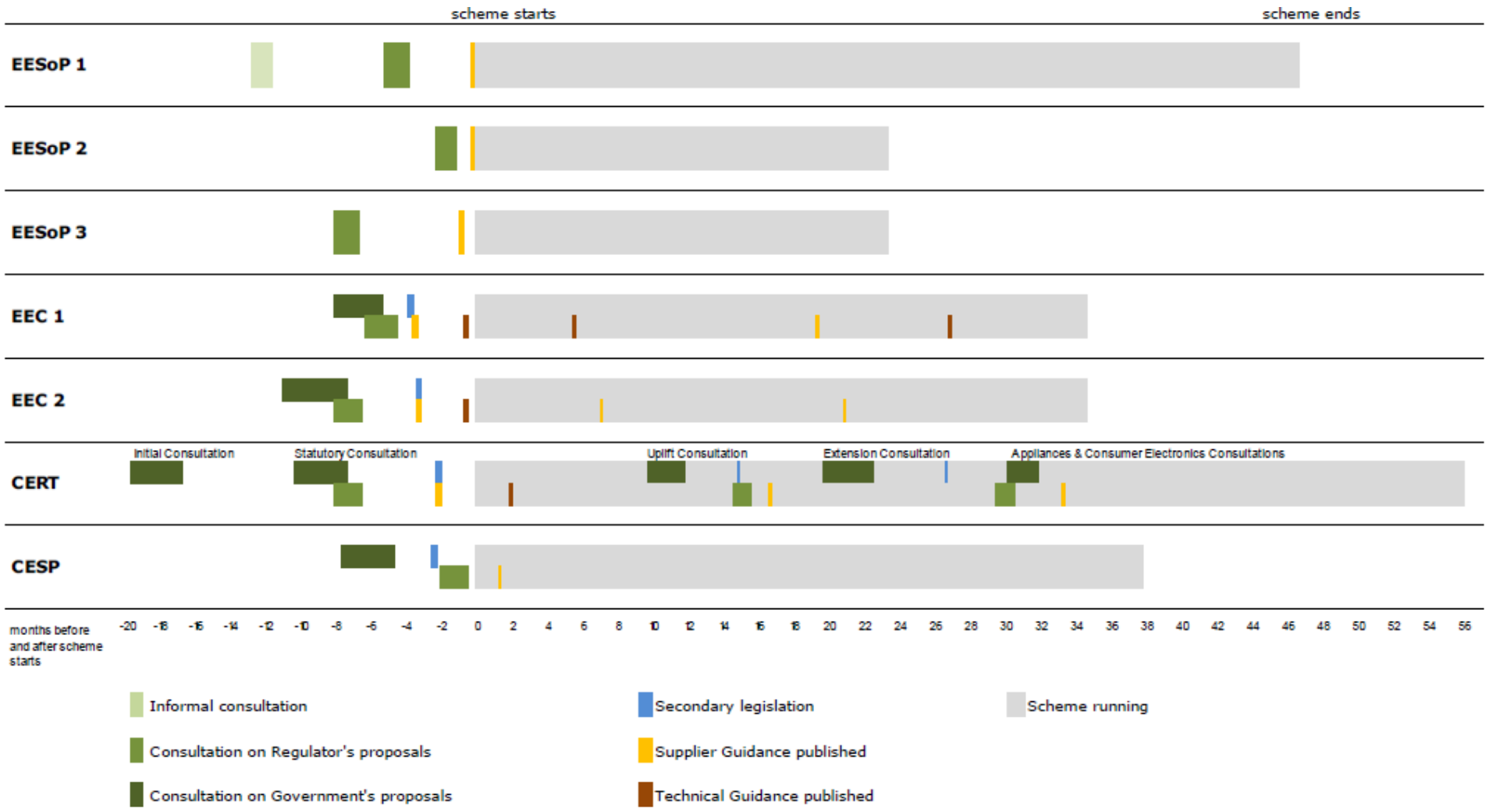


Figure 6: Timeline of past consultations & guidance for EEO schemes in Great Britain (Rosenow, 2012b)

3 Stakeholder engagement

3.1 Approach

The purpose of the stakeholder engagement was to understand stakeholder views relating to energy efficiency in NI. A semi-structured format was followed by asking open questions regarding the following topics relating to energy efficiency in NI:

- Current barriers
- Suggestions for the future
- The potential role of district councils
- Targets and monitoring
- Delivery mechanisms and bodies

A mix of group discussions and individual discussions were carried out. Most of the discussions were completed by telephone during the 2020 Coronavirus crisis. The stakeholders presented in Table 7 were contacted for feedback from January to June 2020. The first column lists the stakeholders contacted by email or phone in order to arrange an interview, but ultimately it was not possible to arrange because either the stakeholder declined or was not able to prioritise engagement due to other demands on their time. The second column presents the list of stakeholders that were interviewed directly, or in one instance, feedback received by email. Descriptions of the second group of stakeholders (that were directly engaged with) are provided in Appendix B.

Table 7: Stakeholders contacted (left) and directly engaged with following contact (right)

Initial contact made	Interviews held or feedback received
• Antrim and Newtownabbey Council • Belfast City Council • Bryson Energy • Business in the Community • Construction Employers Federation (CEF) • Evermore • Major Energy Users Council • Manufacturing NI • Ministerial Advisory Group for Architects and Built Environment • Northern Ireland Building Regulations Advisory Council • NIE Networks • System Operator for Northern Ireland (SONI)	• Consumer Council NI • DAERA • Department of Finance • Department for Infrastructure • Derry City and Strabane District Council • Energy Saving Trust NI • Federation of Small Businesses • Invest NI • National Energy Action NI • Northern Ireland Authority for Utility Regulation (“Utility Regulator”) • Northern Ireland Federation of Housing Associations • Northern Ireland Housing Executive • Northern Ireland Local Government Association • Queen’s University (Centre for Advanced Sustainable Energy) • Royal Society of Ulster Architects • Scottish Government

	• Sustainable Energy Authority of Ireland • University of Edinburgh regarding Scottish Government policy • University of Ulster

3.2 Findings

3.2.1 Current barriers

Stakeholders expressed that it is challenging to define what has made an impact on energy efficiency in NI. There was an acknowledgement of the number of energy efficiency programmes that have been happening, but that some of the programmes had deficiencies in terms of their delivery and didn't necessarily have the impact that would have been desired.

Stakeholders recognised, without prompting, two of the market barriers descried in Section 2.2 of this report: capabilities, and lack of awareness.

With regards to capabilities, a skills gap in the energy efficiency market was frequently referred to. It was commented that companies lack required skills and resources to provide the goods and services required to deliver energy efficiency. It was also suggested that firms do not effectively communicate the benefits of going beyond minimum standards for energy efficiency.

With regards to lack of awareness, a theme emerging from the engagement was that it has not always been obvious where to go for energy efficiency support to bring people to the point of choice. More generally, it was also felt that there is a low public awareness to energy efficiency and that this can present a barrier to domestic energy efficiency. For non-domestic energy efficiency, it was felt that there is a low awareness of the long-term benefits of going beyond minimum standards for energy efficiency in the design of new, or retrofitting of, buildings. This aligns with our literature review, where it was noted that a common barrier is the tendency for companies to pick lowest cost measures and 'low hanging fruit' rather than a focus on long-term cost savings and more difficult installations.

More generally, conversations revealed the importance of the 'point of choice' where the consumer (residential or non-residential) recognises the need, or the opportunity, to do something in terms of energy efficiency. It was felt that there hasn't been large-scale impact to help organisations or individual consumers at the point of choice. The conversations revealed other barriers to energy efficiency, particular to NI. It was expressed that the diversity of building stock in NI[12] presents a challenge, in terms of equality of access to energy efficiency programmes, between urban and rural buildings and considering the high use of oil for heating in the latter.

It was also commented that energy efficiency support for non-domestic buildings, for example the Energy Efficiency Loans Fund (EELF), has typically been targeted towards retrofitting *existing* buildings. However, the support for promoting energy efficiency in *new* non-domestic buildings is viewed as an area that could be improved.

[12] See Appendix D, Figure 44 which highlights differences in the adoption of cavity wall insulation by tenure and location, and Figure 45 which presents EER by tenure and location. Small villages/hamlet/open country homes have a noticeably lower EER, with less than 30% dwellings in band A-C, 42% of dwellings in band D, 22% in band E and 8% in band F (Housing Executive and National Statistics, 2016).

For the EELF, there was more of a focus on process or equipment energy efficiency, and perhaps not enough on building fabric efficiency to reduce heat loss. It was speculated that the focus for manufacturing companies is on improving their process efficiency and resilience of process equipment in order to maintain and increase product throughput, and decrease costs per unit of product. Conversely, energy use for heating is often viewed as a relatively insignificant overhead that cannot be affected. Another possible explanation is that is it more difficult to quantify potential savings from reduced heat loss, for example, from installing roller-shutter doors. Although not commented on during stakeholder engagement, another hypothesis can be drawn from behavioural science whereby people rely on how easily energy-consuming equipment can be retrieved from memory to deduce energy consumption (Kahneman & Frederick, 2002). So, process equipment receives a greater level of attention for energy saving measures since people interact with it more than, say, a heating boiler or warm air blower (Schley & DeKay, 2015). The output of lighting is also suggested as being more salient than that of other energy uses (Kempton & Montgomery, 1982).

3.2.2 Suggestions for the future

Grant programmes were felt to be the most successful type of support. Grants are the main factor in helping people make the 'point of choice' decision, although it is helpful when this goes hand-in-hand with awareness raising and working in partnership with industry and consumers. Even small grants can send a valuable 'ethical signal'. It's important to keep the process simple, and a one-stop shop (OSS) was thought to be beneficial. Stakeholders felt that an OSS could help people know where to go for advice, understand the available opportunities, and understand the returns that can be achieved.

The quality of outcomes in terms of the installed measures is of the utmost importance, and stakeholders identified the need for programmes to work with the supply chain to mandate levels of quality.

Whilst building regulations operate as a minimum standard that can reasonably be attained, change in the market can help forge uplifts and further development. For example, specifying that new social housing must be constructed to better than building regulations minimums (e.g. Code for Sustainable Homes (CSH) Codes,), helps to establish a 'reasonable standard' that building regulations might later require the other sectors to also meet. Without these standards being routinely met in the public sector, such uplifts can be seen as an 'unreasonable adjustment' for the private sector new builds.

3.2.3 The potential role of district councils

There was some understanding that district councils could play a role in an OSS, as potential local points of contact. Some of the existing hub programmes within district councils could play a role with this aspect. An increase in capacity for the understanding of energy management within councils would be beneficial.

Another aspect is about community planning. Community Planning Partnerships have been established in each district comprising the council, statutory bodies, energy agencies and the wider community, including the community and voluntary sector. Community plans identify long-term priorities for improving the social, economic and environmental well-being of

districts and the people who live there.[13] Stakeholders were keen to explore how the strength of community planning in NI could support energy efficiency at a local level.

However, engagement also revealed a view that it would be advantageous for NI to have one central agency (one-stop shop) rather than 11 distributed agencies in the form of district councils.

3.2.4 Targets and monitoring

There was a concern that there is not currently adequate data in terms of focus, consistency, availability, and applicability. If data is available in the right format, it can be used to inform setting and monitoring of targets, and can be used for geo-targeting of interventions. For example, in the RoI, Building Energy Rating (BER) data[14] is being used to inform the design of energy obligations coming forward for suppliers. Another comment highlighted the potential benefit of Building Passports to allow the full construction SAP data to remain available after a new home is built, rather than using less accurate Reduced Data SAP (RdSAP) for subsequent EPCs for the same dwelling.

There were some related comments regarding policy design. For example, it was noted that the Warm Homes Scheme that ran from 2001 to 2015 measured EERs before and after energy efficiency interventions, but this is not done for the current Affordable Warmth Scheme (ongoing since 2015). It was speculated that since the Affordable Warmth Scheme is a fuel poverty scheme (helping people to live in warm and comfortable homes) rather than energy efficiency explicitly, the measurement of EER was not built into the programme because it is not one of the main objectives (although improvements should be reflected in improved EERs).

It was felt that the lack of overall energy efficiency target for NI may be a contributory factor to schemes such as Affordable Warmth not tracking progress. Without the national target, it was thought that there is less incentive and drive to deliver on energy efficiency.

3.2.5 Delivery mechanisms and bodies

A key element for unlocking energy efficiency is the support that the finance sector can provide. Low-cost finance options need to be part of the design process, as opposed to part of an expected end solution. The opportunity for low-cost finance to be provided for low-carbon technologies was highlighted as particularly relevant.

It was commented that NI should be looking at ways in which it could use alternative finance schemes, other than classic grant schemes, to help unlock choice for consumers. These could include low-interest loans, or innovative finance with schemes with energy suppliers. For the latter, the RoI's EEOS was highlighted as a programme with quality-assured energy efficiency interventions delivered by energy companies. Their financing comes through the obligations on energy suppliers and distributors.

[13] https://www.communities-ni.gov.uk/articles/community-planning
[14] https://www.seai.ie/technologies/seai-maps/ber-map/

4 Modelling

4.1 Overview of our approach

Our modelling approach is summarised in Figure 7 below. This chapter sets out our inputs, in particular:

- The NI building stock (see section 4.2),
- Our approach to determining the policy levers and retrofit measures to be modelled (see section 4.3),
- The scenarios we have developed to model and test the impact of different approaches (also section 4.3), and
- Our findings from this modelling process (section 4.4).

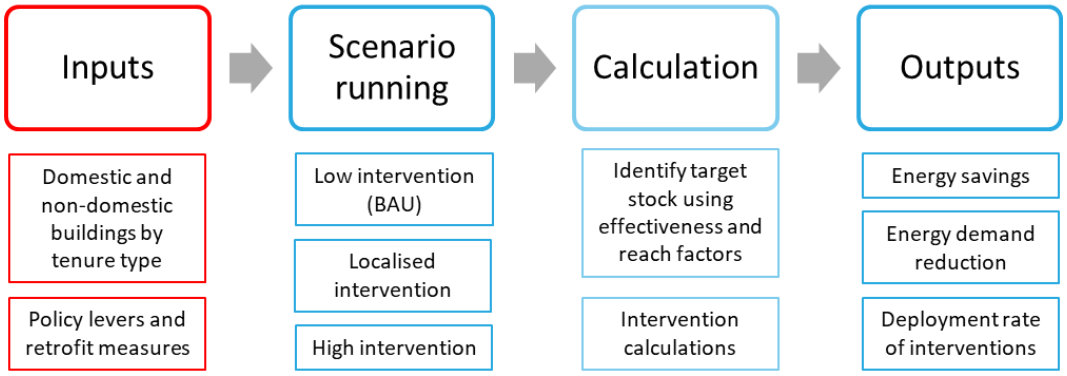


Figure 7: High level methodology diagram for modelling process.

The calculation process for each scenario undertaken in the modelling can be split into three steps including the generation of outputs, as indicated by Figure 7. These are as follows.

4.1.1 Step 1: Magnitude of policy lever is determined

Magnitude (total number of buildings targeted) of policy lever =
Eligible buildings x Reach Factor x Effectiveness factor

A definition of, and description of, the method used to develop the number of eligible buildings, Reach factor and Effectiveness factor is provided in section 4.4.2. For each building stock group, the number of eligible buildings (without existing intervention) is refined using the Reach and Effectiveness factors to determine the total building stock which will be affected by each of the interventions under a given lever. This calculation is undertaken for each combination of levers, building stock groups and interventions to result in total retrofit numbers for each scenario.

4.1.2 Step 2: Deployment of the policy lever applied

The second step takes the results of the first and applies the deployment profiles, corresponding to the stages described in the above section. This determines the total number

of retrofit interventions which take place in each year for each of the policy levers and building stock groups. The total number of interventions over the full time series is equal to the figure determined in Step 1.

4.1.3 Step 3: Analysis and summary

Following the second step, the raw intervention numbers are then used to calculate a number of metrics on an annual and cumulative basis, including:

- Total building retrofits
- Deployment by intervention
- Deployment by policy lever
- Energy demand and demand reduction
- Total investment requirements
- Job creation implications.

These calculations are applied to each of the modelled scenarios to create comparative graphs. The results are presented in section 4.5.

4.2 Limitations

This methodology and the outcomes of this research have limitations due to incompleteness or unavailability of data. This section provides a summary of these limitations and an indication of their impact.

- **Building stock retrofits and housing conditions data:** While the House Condition Survey dataset is relatively comprehensive, assumptions had to be made relating to some metrics which were absent. In particular the dataset does not distinguish between different types of wall insulation or the types of walls properties may have. The data relating to loft insulation could be more granular regarding the thickness of insulation different properties have installed. For this analysis, assumptions were used to estimate the proportion of properties that already have loft insulation and could benefit from further improvement. The overall impact of these is that eligible building numbers could vary, however the numbers used in this modelling represent our best estimation based on all the available data.
- **Policy deployment data**: There is little data which quantitatively describes how different groups of policies could be expected to be deployed over the next 30 years, however the Clean Growth Strategy and CCC targets have been used together with our experience to shape the policy lever deployment. The impact of changing deployment years would result in changes to the projected deployment of retrofits. However, the results of our analysis should be taken to be indicative of what is possible under different circumstances and form a starting point for policy design and implementation, rather than being taken as a forecast of what all policies under a particular lever group would mean for building retrofits.

4.3 The Northern Ireland building stock

4.3.1 General overview

The NI building stock comprises 798,971 dwellings as of April 2018 (Department for Communities, 2019) and ca. 73,000 non-residential buildings (Delorme & Neely, 2016), including 4,300 government-owned buildings (Strategic Investment Board (SIB) and NICS Departments, 2020). The energy consumption of the residential building stock is 13,900 GWh, while the non-residential buildings consume ca. 9,387 GWh/year (BEIS, 2019a), including about 1,970 GWh/year consumed by government-owned buildings (Strategic Investment Board (SIB) and NICS Departments, 2020).

The dwellings are distributed across the 11 Local Council Areas reasonably evenly, except for the Belfast Metropolitan Urban Area (BMUA), which includes about twice as many dwellings as the average. Figure 8 indicates the growth plans for each local council area in terms of additional housing units between 2020 and 2030, assuming a constant number of dwellings being built per year (see Appendix C for details). The estimated growth of the residential building stock is about 11% in the next 10 years.

Figure 8: Projected new housing units between 2020 and 2030 according to Local Council Areas development plans (see Appendix C)

The NI residential building stock comprises a variety of dwelling types: bungalows, terraced houses, semi-detached houses, detached houses which are present in comparable proportions, except a minority (7%) of flats/apartments (Figure 9).

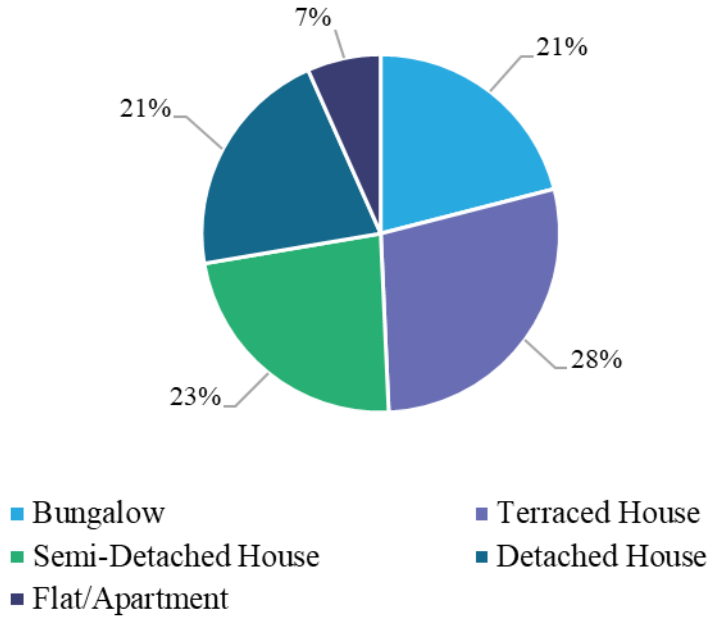


Figure 9: The categorization of the Northern Irish residential building stock per dwelling type

Northern Irish residents tend to own their houses (NIHE and National Statistics, 2016), with 70% of dwellings being owner-occupied, mostly owned outright (42%), but also owned with mortgage (28%). About 13% of all dwellings are privately rented, and 12% are owned by the NIHE (Figure 10).

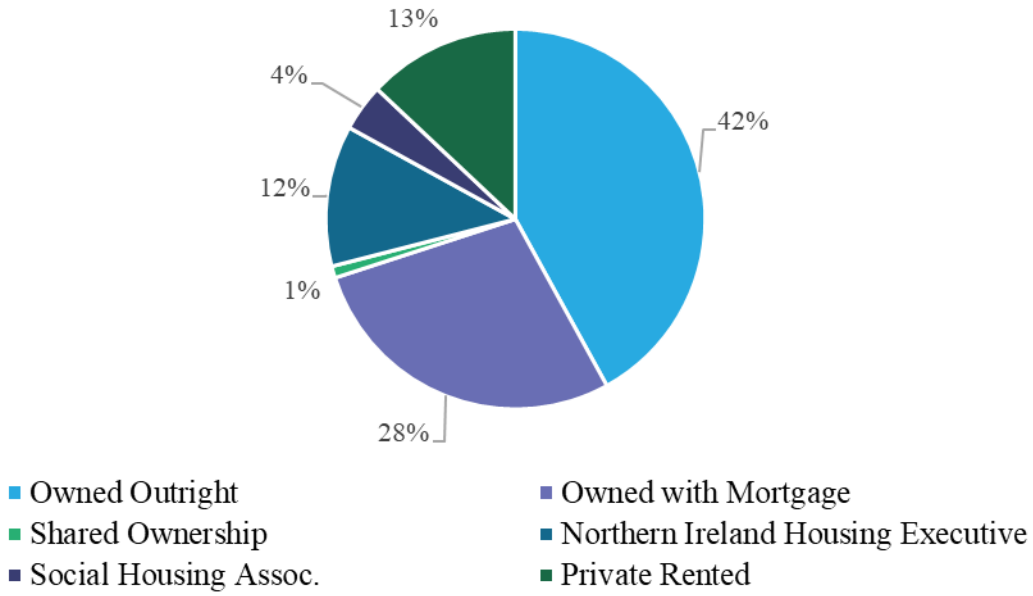


Figure 10: The categorization of the Northern Irish residential building stock per tenure type

Table 8 reports the number of buildings for the residential building stock by tenure type as assumed in our modelling.

Table 8: The residential building stock by tenure type (DfC, 2019)

Tenure type	Number of buildings
Owned Outright	335,568
Owned with Mortgage	223,712
Shared Ownership	7,990
NIHE	95,877
Social Housing Assoc.	31,959
Private Rented	103,866
Total	**798,971**

The typology and tenure of non-residential buildings was taken from the Land & Property Services (LPS) valuation list provided by the Department of Finance (2018). It was found that approximately 1,900 buildings are educational buildings (nurseries, primary and secondary schools), 1,500 buildings represent the health sector (hospitals, clinics, surgeries, care homes), 1,300 buildings are other government-owned buildings (libraries, law and order establishments, defence hereditaments and coast guard, miscellaneous public service properties) and the remaining are SME and large enterprises.

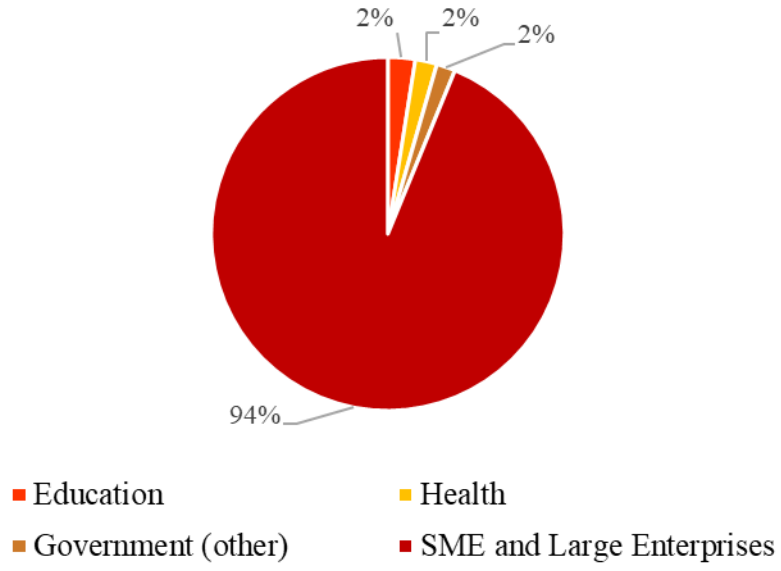


Figure 11: The categorization of the NI non-residential building stock per tenure type

Precise data about the split among small and medium sized enterprises (SMEs) and Large Enterprises was not available[15]. As a proxy of this categorization, it is possible to refer to the Inter Departmental Business Register published by Northern Ireland Statistics and Research Agency (NISRA) (2019), where the data shows that only 0.4% of total enterprises in NI employ over 250 employees (Figure 12). In the absence of better data, we took two different numbers for Large Enterprises buildings: 227 (as if there was a 1:1 ratio between number of buildings and number of enterprises) and 2,270 (as if each Large Enterprise operated 10 buildings). The sensitivity study showed a negligible influence on the results when considering 227 or 2,270 buildings.

[15] Small and medium sized enterprises (SMEs): any business with fewer than 250 employees. Large enterprises: any business with more than 250 employees.

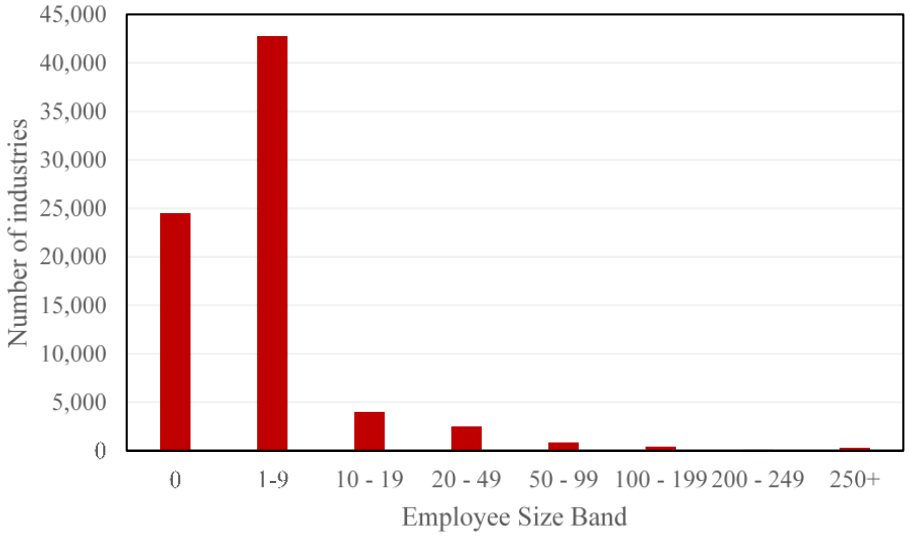


Figure 12: Number of VAT and/or PAYE Registered Businesses Operating in NI by Employee Size Band, 2019 (NISRA, 2019)

The table below shows the categorization of the non-residential building stock according to building use. The assumption of a 1:1 ratio between number of buildings and number of Large Enterprises is made.

Table 9: Destination of use of the non-residential building stock

Building use	Number of buildings
Education	1,854
Health	1,476
Government (Other)	1,277
SME (Owned and Rented)	69,381
Large Enterprise (Owned and Rented)	227
Total	**74,216**

Based on the data presented above, the table below summarises the modelling assumptions related to the description of the building stock and the quality of the data they are based on.

Table 10: Modelling assumptions and data quality: NI building stock

Aspect	Data Source	Data Quality
Number of buildings (residential)	Department for Communities (2019)	Very High: National Statistics, Updated
Number of buildings (non-residential)	Delorme & Neely (2016)	Low: Approximate EBPD data, Outdated
Building typology and characteristics (residential)	NIHE and National Statistics (2016)	High: National Statistics, 2016
Building typology (non-residential)	(Department of Finance, 2018; Northern Ireland Statistics and Research Agency (NISRA), 2019)	Medium: Classification from LPS non-corresponding to model classification, split among SMEs and Large Enterprises – and their tenure – not available

Aspect	Data Source	Data Quality
Building tenure (residential)	NIHE and National Statistics (2016)	High: National Statistics, 2016

4.3.2 Energy data

The NI building stock is largely dependent on oil for heating. Belfast is the only local council where gas has a higher penetration than oil when considering the overall energy use of the residential building stock (NIHE and National Statistics, 2016) (Figure 13). Gas is the most common type of Central Heating only in Social Housing and in the BMUA, while it is virtually absent in villages. Elsewhere, oil is the most common type of Central Heating in NI (>80% in Small/Medium Towns and villages, >70% in Owner Occupied and Private Rented). Please refer to Appendix D for the complete breakdown of Central Heating per tenure type and location.

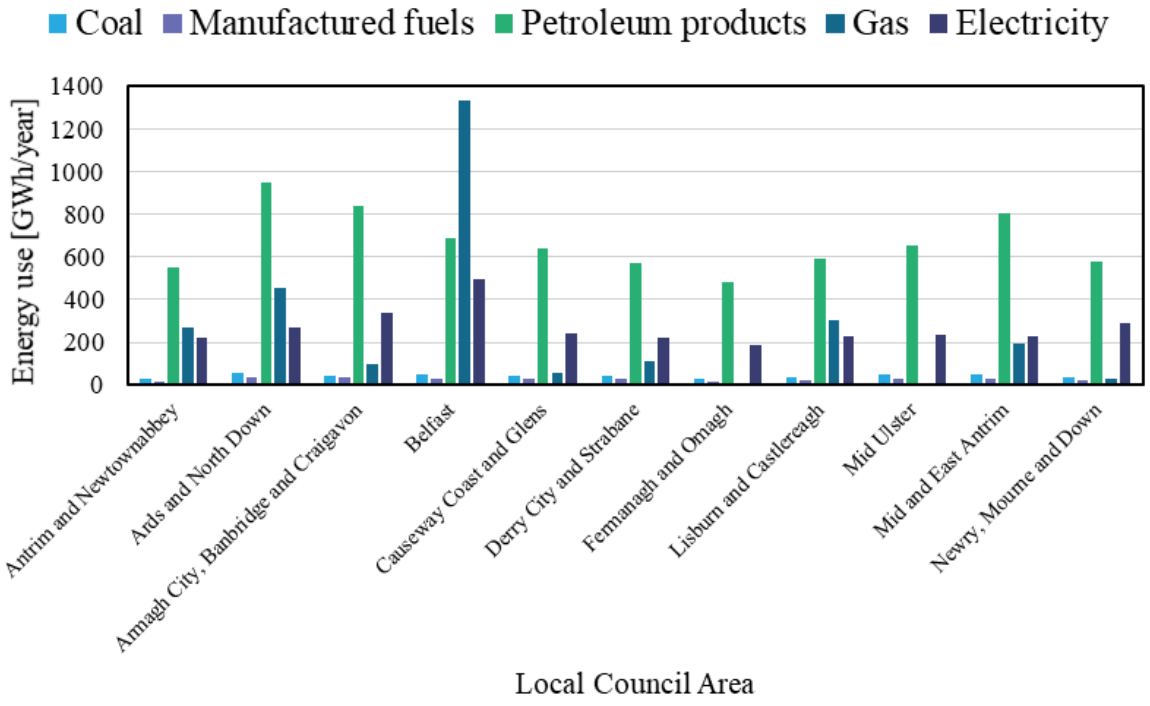


Figure 13: Energy Use in the residential sector per fuel type

The NI building stock is generally characterised by good levels of wall insulation, with Full Cavity Wall Insulation present in 65% of dwellings across all tenure types and locations. Loft Insulation also has a high adoption, with greater than 50% of dwellings in most tenure types and locations having more than 150 mm insulation thickness, with no significant difference across tenures and locations). However, Technical Booklet F1 (Conservation of fuel and power in dwellings) (Department of Finance and Personnel, 2012) states a typical cost-effective insulation thickness for lofts should be 270 mm and therefore there would appear to be some room for improvement from the NIHE House Condition Survey.

Similarly, the existence of double glazing is significant, with greater than 85% of all dwellings having full double glazing across tenures and locations (please refer to Appendix D for the full breakdown of building characteristics by tenure and location) (NIHE and National Statistics, 2016).

The chart below presents the distribution of EERs for dwellings in NI (Department of Finance, 2020). The most common (mode average) rating is 67 (D rating) and the mean average is 61 (D rating).

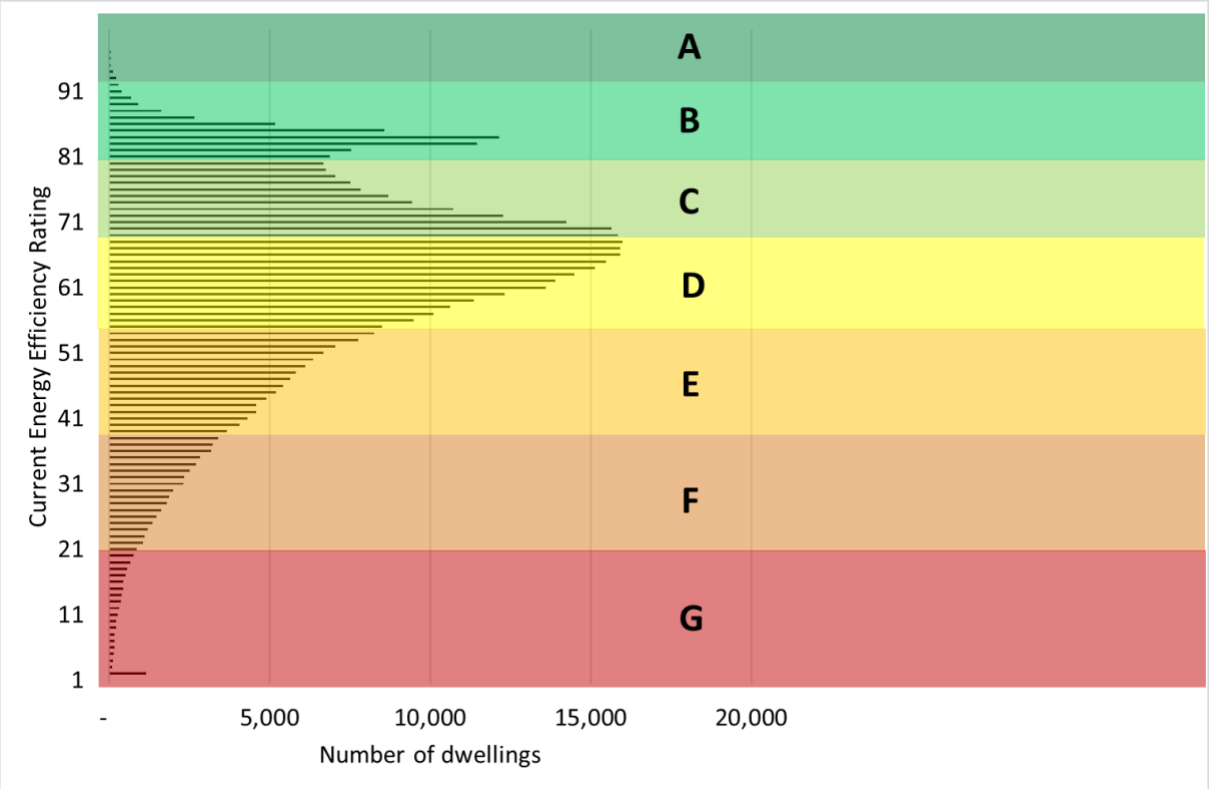


Figure 14: EERs for dwellings in NI. Created from data supplied by Department of Finance (2020). Note that the above is illustrative, and the data may contain multiple EPC lodgements for the same building, which cannot be ascertained from the data supplied to Arup.

A large discrepancy across building tenures and locations can be noticed in results derived from EPC data by the NIHE and National Statistics (2016), see Figure 45 in Appendix D). Most Social Housing (79%) dwellings and most dwellings in the BMUA (66%) are in band A-C. Small villages/hamlet/open country homes have a noticeably lower EER, with less than 30% dwellings in band A-C, 42% of dwellings in band D, 22% in band E and 8% in band F (NIHE and National Statistics, 2016).

The EPC data (Department of Finance, 2020) allows for a GIS representation of the NI residential building stock per outward code (the first half of the postcode which identifies the town or district). Figure 15 shows how most outward codes are characterised by an average EER of D, which indicates significant room for improvement of the energy efficiency across the residential building stock. Only in the BMUA two postcodes have average EER of B and two different postcodes have average EER of C. It is worth reminding that EPC data present reliability issues for several reasons, such as measurement errors, occupant behaviour, long periods of validity despite changes to the building, etc. (Pascuas, Paoletti and Lollini, 2017; Crawley et al., 2019). Nevertheless, they provide an indication of the building stock. Additional GIS representations of the building stock in terms of energy consumption are available in Appendix E.

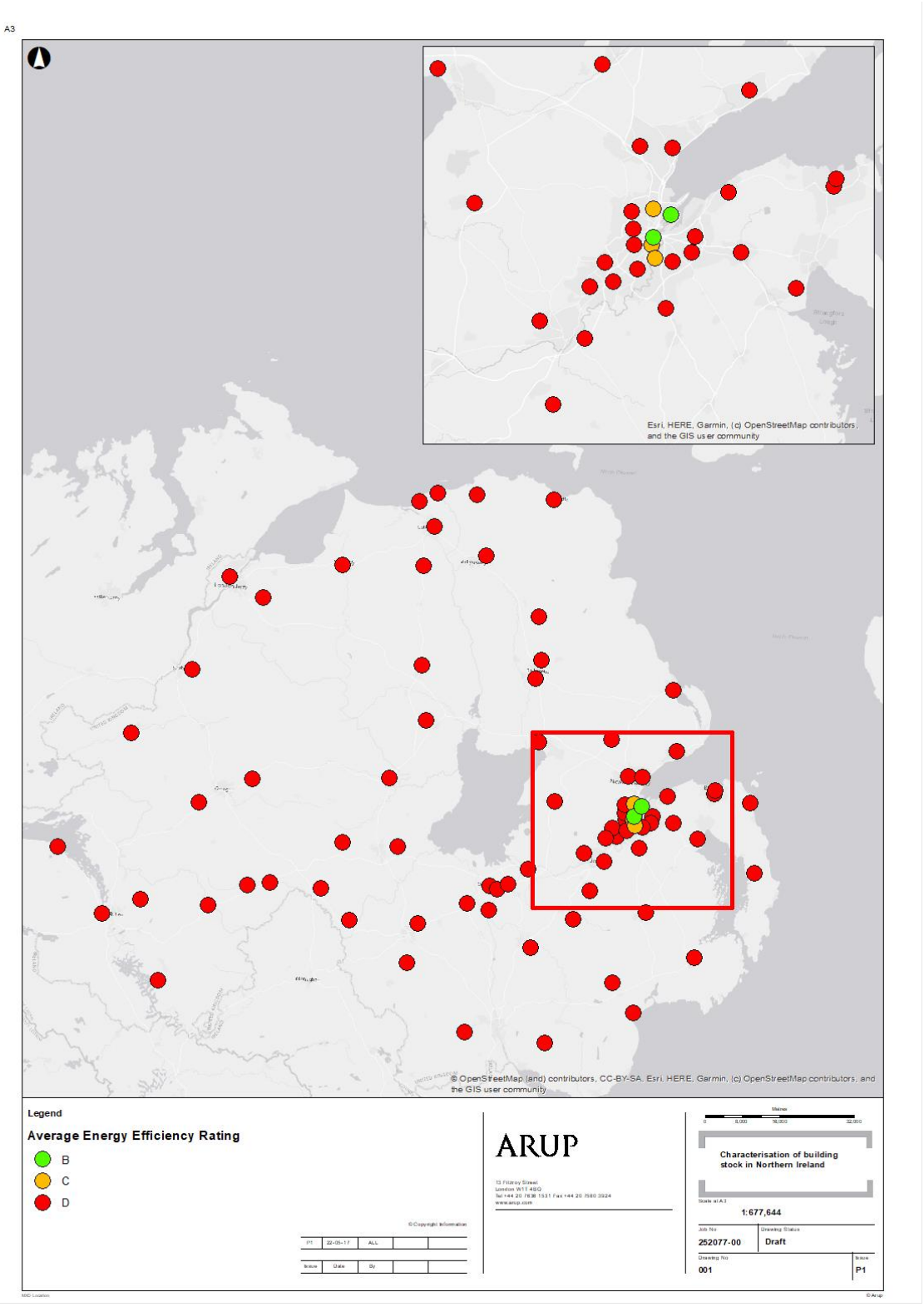


Figure 15: Average EER per postcode outward code (residential building stock)

The data for EPC of the non-residential building stock is available for the aggregated building stock (no distinction among sectors is made) (Delorme & Neely, 2016) . Virtually zero buildings are in EPC band A. Most non-residential buildings are in EPC band C (29%) and D (25%), followed by E (15%) and G (12%).

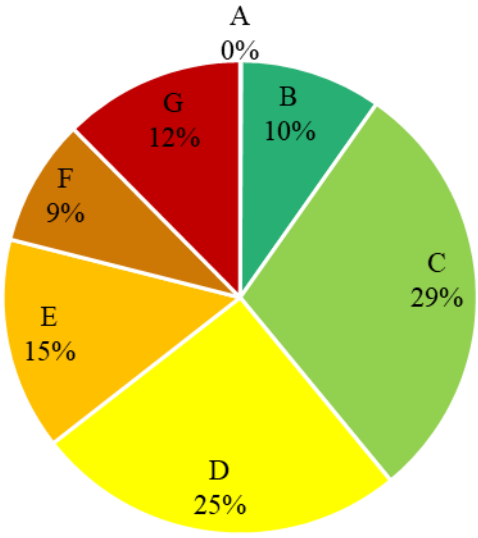


Figure 16 : EER for the non-residential building stock

Apart from EPC data, a necessary input to our modelling is the current energy demand for space heating, domestic hot water (DHW) and electricity for the building stock (both existing buildings and new builds) by tenure type expressed in kWh per year. The assumptions made for the residential building stock are reported below (Table 11).

The data for the mean electricity demand of a dwelling in NI is reported by BEIS (BEIS, 2019f) which states that, for example, the yearly mean electricity consumption of a dwelling in Northern Ireland in 2017 was 3,610 kWh. The data related to the energy demand for space heating and domestic hot water (DHW) is expressed in terms of total use by energy vector (e.g., gas, petroleum, coal) and does not make any explicit reference to the split between space heating and DHW (BEIS, 2019a). In this report, we assume – in agreement the European directive for final energy consumption in the residential sector by end use (Eurostat, 2019) – that the amount of energy needed for space heating is four-fifths of the total and DHW production is one-fifth of the total. In the same report (Eurostat, 2019), it is indicated that the energy for space heating and DHW production covers about 79% of the total energy demand of a dwelling. Based on this information, alongside the total energy use of the NI domestic sector by BEIS, the assumptions for average energy demand of a dwelling in NI are made in Table 11.

Moreover, it is assumed that the energy demand for DHW and electricity are not dependent on tenure type. The tenure-type dependency of energy demand for space heating mirrors the fact that owner-occupied dwellings tend to have a larger surface area, thereby needing more energy for space heating.

Table 11: Average energy demand for a residential dwelling. Data source: BEIS (2019e) (Existing).

Building type	Demand type	Existing [kWh/yr]	New build [kWh/yr]
Owned outright	Heating	11,506	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890
Owned with mortgage	Heating	11,506	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890

Building type	Demand type	Existing [kWh/yr]	New build [kWh/yr]
Shared ownership	Heating	9,060	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890
District owned	Heating	9,060	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890
Social housing assoc.	Heating	9,060	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890
Private rented	Heating	9,060	1,581
	DWH	2,527	1,466
	Electricity	3,610	2,890

Table 12 presents the assumptions made for the energy demand of various types of non-residential buildings. The values for existing health, education, and government (other) buildings correspond to the median energy demand for each category reported (Strategic Investment Board (SIB) and NICS Departments, 2020). The median is considered as opposed to the mean value to avoid overestimations due to outliers. The assumptions for SMEs and Large Enterprises, as well as all assumptions for new builds, are taken from Arup experience on previous projects.

Table 12: Average energy demand for a non-residential building. Data sources: (Strategic Investment Board (SIB) and NICS Departments, 2020) (Existing) and Arup experience (work for Greater London Authority).

Building type	Demand type	Existing [kWh/yr]	New build [kWh/yr]
Health	Heating	151,419	15,230
	DWH	92,284	12,868
	Electricity	145,272	38,357
Education	Heating	79,570	20,502
	DWH	45,592	18,431
	Electricity	96,286	78,888
Government (other)	Heating	27,636	3,621
	DWH	16,635	3,067
	Electricity	60,053	20,666
SME	Heating	31,508	5,089
	DWH	13,031	3,984
	Electricity	56,323	21,106
Large Enterprise	Heating	36,164	6,947
	DWH	15,126	5,190
	Electricity	56,599	22,600

Figure 13 presents our assessment of the data quality of the sources of energy data.

Table 13: Modelling assumptions and data quality: Energy performance

Data	Data Source	Data Quality
EER (residential)	NIHE and National Statistics (2016)	High: National Statistics (2016)
EER (non-residential)	Delorme & Neely (2016)	High: EPBD data (2016)
Average energy demand – existing (residential)	BEIS (2019e) (Existing buildings)	Very high: BEIS, Published 31 October 2019
Average energy demand – existing (non-residential)	Strategic Investment Board and NICS Departments (2020)	High: (Education, Health, Government (other)): median of actual data.
Average energy demand – new build (residential)	Arup experience	Medium. This is subject to change and regional differences.
Average energy demand – new build (non-residential)	Arup experience	Medium. This is subject to change and regional differences.

4.3.3 Focus: Government-owned buildings

The nature of the SIB/NICS dataset allows for an in-depth consideration of government-owned buildings (please refer to Figure 48 in Appendix E for the GIS representation of energy use by government-owned buildings). Figure 17 indicates the energy use per fuel type and per department in 2017-2018, which leads to a total of about 1,970 GWh consumed by government-owned buildings during that period. The buildings owned by three departments: DE (Department of Education), DoH (Department of Health) and DFI (Department for Infrastructure) are responsible for most of the energy use.

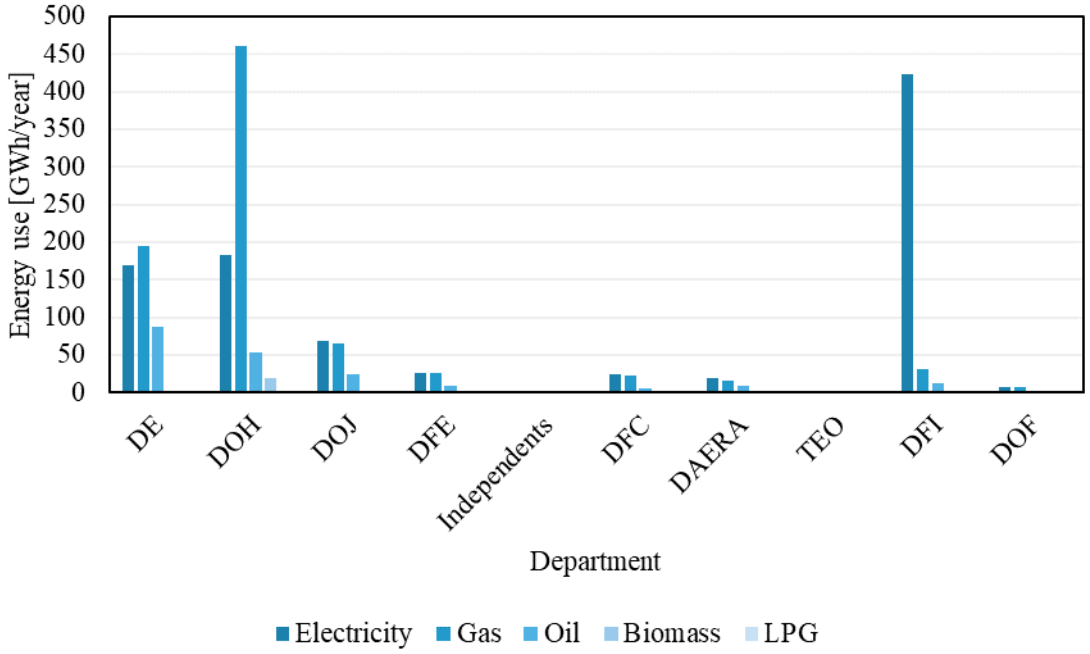


Figure 17: Government-owned buildings energy use per fuel type and department. Note that the high electricity use by DFI appears to be largely due to water pumping ('Building' Water Service and 'Occupier' Water Service at 68% of DFI use) and street lighting ('Occupier' Public Lighting, 25% of DFI use).

Indeed, the 10 government-owned buildings that consume most energy (mapped in Figure 18) cover more than 25% of the energy used by total government-owned building stock (please refer to Figure 48 in Appendix E for more detail). Eight out of 10 of the highest government-owned energy consumers are within DoH.

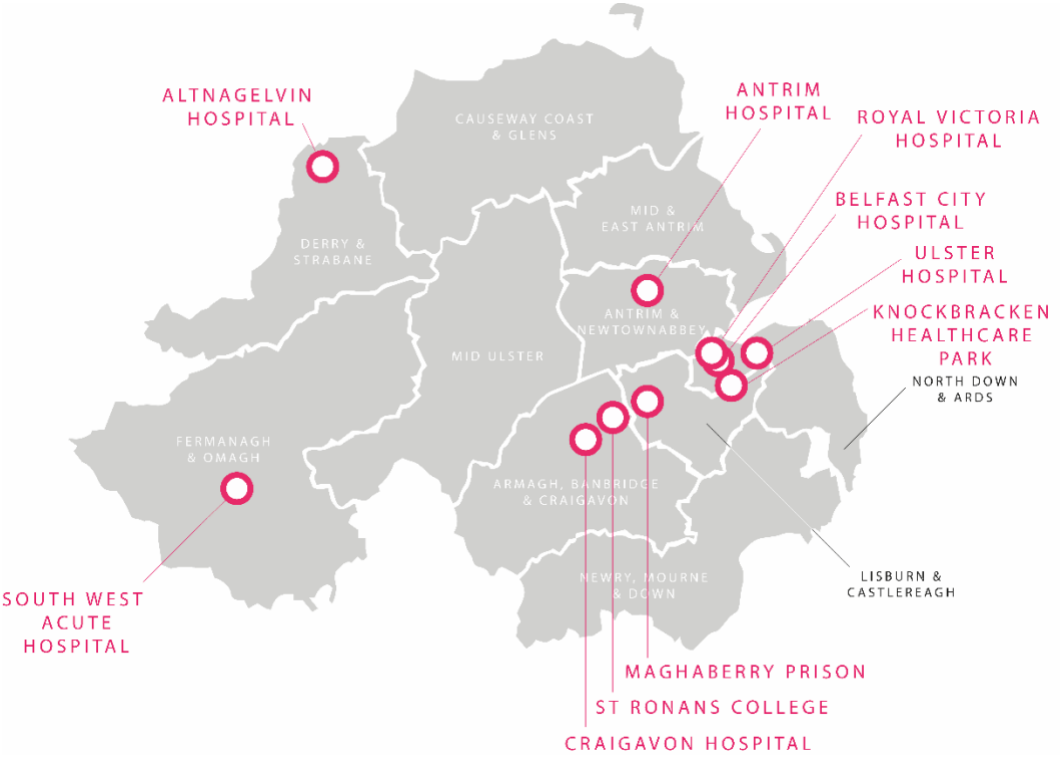


Figure 18: Location of the 10 top energy consumers (government-owned buildings) mapped per local council area

There is a handful of buildings with high energy use, therefore, this may present a good opportunity to efficiently tackle energy efficiency in the government-owned building stock.

4.3.4 Fuel poverty

Fuel poverty in Northern Ireland was reported as 22% of households for the year 2016 (NIHE, 2018)[16]. A household is considered to be in fuel poverty in NI if, in order to maintain a safe and healthy level of heating (21 °C in the main living area and 18 °C in other occupied rooms), it is required to spend in excess of 10% of its household income on all fuel use (NIHE, 2019c).

The areas characterised by highest level of fuel poverty (see Figure 19) – Mid Ulster and Derry & Strabane – are also characterised by the smallest uptake of natural gas.

[16] It is noted by NIHE that fuel prices in 2016 were relatively low and this was a major contributor to the relatively low fuel poverty rate compared to the figure of 42% reported in the 2011 survey. The effect of heating oil price is also reflected in NIHE's lower estimates of fuel poverty for subsequent years when heating oil prices were lower (NIHE, Greene and Brown, 2019).

Figure 19: Rate of fuel poverty across local council areas

Interestingly, the levels of fuel poverty change visibly across tenure types and locations (see Figure 20). The lowest rates of fuel poverty are observed in Social Housing (<10%) and generally in towns (~15%). Conversely, the highest rates of fuel poverty are observed in Villages (27%) and Small Village/Hamlet/Open Country (34%).

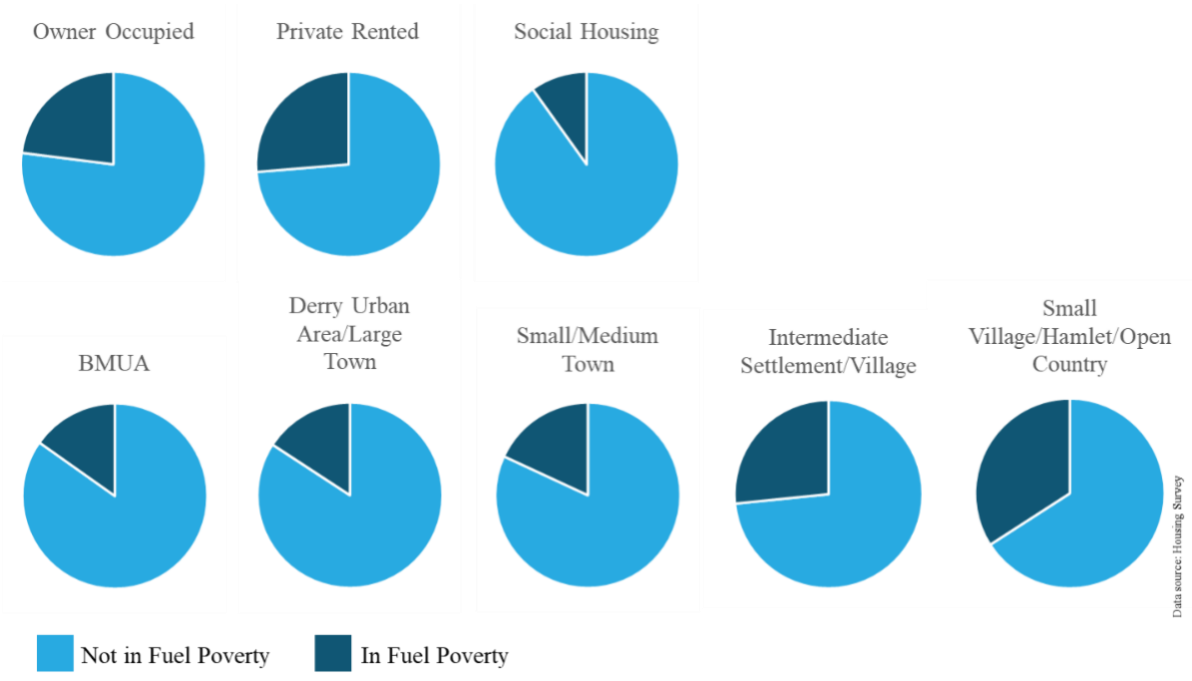


Figure 20: Fuel poverty by tenure and location

4.4 Lever modelling

4.4.1 Scenario development

Three intervention-based scenarios were developed and modelled as part of this work, as well as a business-as-usual (BAU) scenario for comparison.

The BAU scenario was developed based on the following current programmes in NI, suggested by the DfE. Annual energy savings from these programmes were provided by NIHE, Invest NI, and the Utility Regulator:

- NISEP (37 GWh/y).
- Affordable Warmth Scheme (30 GWh/y).
- Invest NI Resource Efficiency Capital Grant (RECG) (0.5 GWh/y).

The savings were assumed to continue uniformly until 2050, based on the assumption that when these policies come to a finish they may be extended, or similar policies will take their place. A potential limitation of this approach is that it may become increasingly difficult to maintain the levels of savings that result from these levers.

The "Low Intervention" scenario is characterised by low levels of funding and resources resulting in low engagement and success in the policy levers introduced. Reach factors for the policy levers in this scenario are typically 5 to 20%, representing low levels of participation from the building typology and tenure groups.

In the "Localised Intervention" scenario, overall strategy and programme for policy lever rollout is driven by the NI Government, but predominantly lead and executed by district councils. This scenario sees improved Reach factors typically in the region of 10 – 40% and includes a greater number of policy levers, however, has slightly delayed deployment of Planning policy and Programme delivery levers compared with the other scenarios to account for the variation in timescales that could come from a less unified approach to these levers.

The "High Intervention" scenario represents the highest levels of funding and resources resulting in higher engagement and success of policy levers. This scenario is characterised by high Reach factors typically 30 to 60% and includes all policy levers.

4.4.2 Policy lever characterisation

Following on from the literature review, a set of policy levers was identified. These were then characterised based on the groups of fuel poverty and domestic and non-domestic building tenures they are expected to impact, and mapped against energy efficiency interventions which they are likely to facilitate. Table 14 presents a description and examples for each lever, and behavioural barriers targeted by the lever. A summary of the features for each lever is shown in Table 15.

Table 14: An overview of policy levers including a description and examples

Policy lever	Description	Examples	Behavioural barriers targeted by the lever
Funding – grants	The availability of grants for building energy efficiency improvements.	NISEP. Warm Homes Scheme. Affordable Warmth Scheme. RECG. ECO.	High upfront costs. Lack of capital.
Funding – loans	The availability of loans for building energy efficiency improvements.	Invest NI Energy Efficiency Loan Fund.[17] HEEPS Warmer Homes Scotland.	High upfront costs. Lack of capital.
Programme delivery	Local or national government action to appoint supply chain partners for the rollout of retrofit in buildings.	Warm Homes Scheme. Arbed.	Ignorance. Inertia / Other priorities.
Other financial incentives	Financial incentives such as rates or stamp duty incentives.	Netherlands: Energy Investment Allowance. Council tax variation by EPC.	Some consumer segments might not be reached due to unawareness or misalignment of targeted policy.
Standards	Minimum EE standards, EU appliance standards.	MEES in England, Wales, and the Netherlands. Proposed MEES in Scotland.	High upfront costs. Lack of capital. Uncertainty of fuel prices. Ignorance. Inertia / Other priorities.
Building regulations	Minimum building regulations with regards to regulated energy use.	UK Building Regulations – Part L.	Ignorance. Inertia / other priorities.
Planning policy	Policy set by district councils with regards to new developments.	Bristol City Council Policy BSC14.	High upfront costs. Lack of capital. Uncertainty of fuel prices. Ignorance.
Public reporting	Mandate for certain target groups to display and report building energy performance.	DECs. "Be Seen" policy in the London Plan.	Some consumer segments might not be reached due to unawareness or misalignment of targeted policy.
Technical support	Advice for target groups encourage the uptake of interventions.	NISEP Energy Efficiency Networks. Wales Warm Homes Nest and Arbed schemes. KfW special fund for energy efficiency in SMEs.	Some consumer segments might not be reached due to unawareness or misalignment of targeted policy.

[17] Closed to new applications in June 2018.

4.4.3 Reach and Effectiveness factors

For each policy lever, two metrics have been established:

- a *Reach factor*; and
- an *Effectiveness factor*.

Reach factor

Reach represents the proportion of the eligible building stock targeted for retrofit through any given policy lever. It is assumed under the 'High' scenario, and in the context of achieving net-zero emissions from buildings in 2050, all or almost all eligible buildings will be targeted by each of the policy levers. This *would* mean the Reach factor for all policy levers is 100%. However, many of the policy levers overlap in terms of the building groups targeted for installation of the different interventions. For the 'High' scenario, we applied reductions to the Reach factor for targeting a specific building group to avoid double counting or summing interventions to more than 100% of eligible buildings (see values in Table 15). The method used to determine the reduced Reach factor accounts for the following:

- Policy levers that comprise guidelines to be followed by building owners, tenants or the construction industry (e.g. policy, standards, regulation) have a higher Reach factor as there is no practical or financial limit to Reach of that policy lever.
- Policy levers that comprise funding (e.g. grants or loans) or involve the physical delivery of a retrofit programme have lower Reach factors as their uptake potential is limited by the finances attributed to energy efficiency and other practical factors, including supply chain, procurement and the availability of a skilled workforce.

The method used for the 'Localised' and 'Low' scenarios accounted for the expected uptake relative to the 'High' (see section 4.4.1 for the scenarios). However, consideration was also given to the implementing authority of the policy lever (e.g. a proportionally greater Reach was attributed to the 'Planning policy' lever for the 'Localised' scenario because district councils are the implementing authority in this case). Since different policy levers are applicable to different groups of buildings, the Reach factor varies slightly on a case-by-case basis.

Effectiveness factor

The Effectiveness factor is a measure of the success of each policy lever when implemented. It is an inherent quality of a policy measure which aims to reflect the expected successful uptake within the target building group. The literature review carried out as part of this study was used to help determine the Effectiveness factor of the policy levers. These were classified as low, medium or high levels of effectiveness in the literature review, depending on the extent to which they had met their objectives. In order to translate these Effectiveness ratings into our modelling, we carried out the following steps:

- We considered average effectiveness across different geographies
- We considered the inter-relationships between policy levers
- We applied a percentage effectiveness based on the above

There will always be nuances as to how policy is developed and applied in a specific context, and it is possible that in NI, learnings could be taken from elsewhere, and policies made more

effective. However, the method recognises that no policy will ever be 100% effective in achieving the outcomes sought.

The table overleaf provides additional details on the policy levers and typical Reach and Effectiveness factors.

Table 15: Summary of policy lever modelling details, including affected groups, Reach & Effectiveness factors and intervention mapping.

Policy lever	Building groups affected	Key notes on justification	Reach (max)	Effective -ness	Interventions (see Table 17 for full list)
Funding – grants	Existing: All Fuel Poor domestic tenure groups, SMEs	These building groups are more likely to need targeted investment	20%	80-90%	All, except DHW saving measure and building energy operation
Funding – loans	Existing: All Able to Pay domestic tenure groups, Public sector, Large enterprises	Available to all groups except those who are eligible for grants	10%	90%	All, except DHW saving measure and building energy operation
Programme delivery	All existing (Fuel Poor & Able to Pay domestic tenure groups, SMEs, Large enterprises, Public sector)	Only existing building groups would be targeted by this lever, since new properties are more likely to be built with superior design	25%	70%	All
Other financial incentives	Existing: Able to Pay domestic tenure groups excluding District Owned and Social Housing; Large enterprises. New: Able to Pay domestic tenure groups, Large enterprises, Public sector	This lever targets owners and occupiers of existing buildings excluding those owned by the public sector, as well as developers for all types of new buildings except SMEs	40%	70%	All
Standards	All existing (Fuel Poor & Able to Pay domestic tenure groups, SMEs, Large enterprises, Public sector)	This would apply to all existing buildings. New buildings would be expected to already meet standards	50%	70%	All
Building regulations	All new (Able to Pay domestic tenure groups, SMEs, Large enterprises, Public sector)	This is targeted at developers of new buildings	50%	70%	All, except DHW saving measure, heat pumps and lighting & appliance efficiency
Planning policy	All new (Able to Pay domestic tenure groups, SMEs, Large enterprises, Public sector)	Most interventions won't require planning permission in existing buildings	30%	70%	Building energy operation only
Public reporting	Existing and New: All District Owned or Social Housing domestic groups, SMEs, Large Enterprises, Public sector	This targets all publicly owned or operated buildings as well as non-domestic properties	50%	70%	Building energy operation only
Technical support	All existing (Fuel Poor & Able to Pay domestic tenure groups, SMEs, Large enterprises, Public sector)	This targets all existing buildings	20%	70%	All

4.4.4 Lever deployment patterns

For each policy lever a deployment period was also modelled, identifying key stages of implementation for each lever. In most cases, these stages are:

- increasing deployment
- uniform deployment
- decreasing deployment

This results in a trapezoid-like shape with a sustained peak of deployment during the uniform period, illustrated by Figure 21. It is clear from the figure that this approach to deployment identifies four key years, which are:

A. Year of rollout

B. End year of increasing deployment

C. End year of uniform deployment

D. End year.

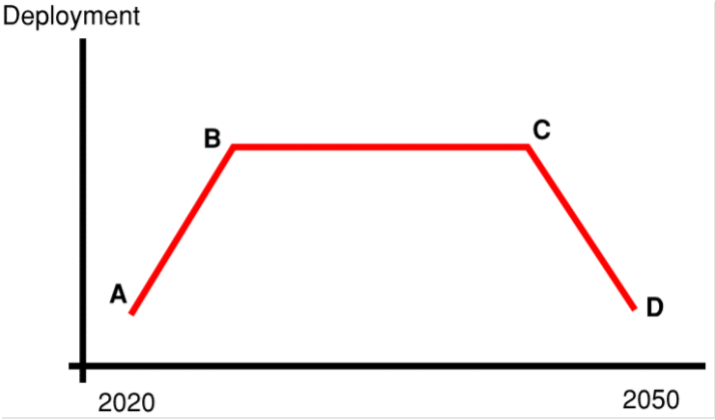


Figure 21: Example of policy lever deployment.

The four stages of the deployment schedule were established after considering the following points for each policy lever individually:

- Lead-in time (e.g. mobilisation of finances/resources/procurement/skills, time required to implement significant change) – Stage A.
- Expected duration of sustained peak of policy lever deployment – Stages B to C.
- Expected completion of policy lever in line with energy demand reduction targets and the sequence of installation of the interventions captured by policy lever – Stage D.
- Correspondence to similar policy levers described by existing literature (e.g. CCC Net Zero report (CCC, 2019c), Clean Growth Strategy (HM Government, 2017)) – all Stages.

The assumptions used for the deployment schedule are provided in Table 16 for the policy levers previously described in Table 14.

For a number of the policy levers modelled as part of this work, deployment is assumed to finish in 2035 or 2040. This approach is in line with decarbonisation strategies in which energy efficiency measures have their main role in earlier stages of decarbonisation, such as

the Future Energy Scenarios (FES) (National Grid, 2019) compared to other decarbonisation measures. By first focusing on policy interventions which reduce energy demand, governments can bring about significant change early on, before other measures are introduced to address residual emissions. A small set of policy levers are modelled to continue deployment until 2050: using the 'carrot and stick' metaphor, these are 'stick' levers, which by their nature continue to have an impact once in place with a reduced need for maintenance and funding, compared to incentive 'carrot' levers.

Table 16: Deployment profiles for the modelled policy levers, with an explanation of how key years were derived.

Policy lever	Deployment Phase				Justification
	A	B	C	D	
Funding – grants	2022	2024	2030	2035	Begins deployment immediately. 2-year ramp up: 1 year to mobilise; 1 year to bring significant change. Sustained peak to 2030 in order to achieve majority of interventions by this date, in line with Clean Growth Strategy and CCC emissions reduction report targets. Gradual decline to achieve difficult remainder until 2035.
Funding – loans	2022	2024	2030	2035	
Programme delivery	2022	2028	2033	2040	Deployment begins immediately. Longer ramp up duration of 5-6 years to bring significant change. Sustained peak through to 2033 in order to achieve majority of interventions close to 2030. Gradual decline to achieve difficult remainder until 2040.
Technical support	2023	2028	2033	2040	
Other financial incentives	2023	2023	2030	2030	Due to nature of policy, immediate ramp up in 2023. Steady impact until end date which comes as other levers take significant effect.
Standards	2023	2028	2033	2050	Begins from 2023. Longer ramp up duration of 5 years to bring significant change. Sustained peak through to 2033 to achieve majority of interventions close to 2030. Gradual decline to achieve difficult remainder until 2050.
Public reporting	2023	2028	2033	2050	
Building regulations	2023	2023	2035	2050	Due to nature of policy, immediate ramp up in 2023. Steady impact until 2035 to achieve majority of interventions close to 2030 in line with Clean Growth Strategy and CCC targets.
Planning policy	2023	2030	2035	2050	7-year ramp up period to establish significant change by 2030 followed by sustained 5-year peak to achieve majority of interventions in line with Clean Growth Strategy and CCC targets.

4.4.5 Intervention characterisation

For the retrofit interventions, data from the NI House Condition Survey (NIHE, 2018) was used to determine what proportion of each building tenure group already has each of the intervention measures and therefore what proportion of the building stock can be considered eligible for the interventions. Where data was not available, assumptions based on Arup's experience have been used to create a complete dataset.

Table 17: The proportion of building tenure groups considered eligible for each of the intervention measures. This is based upon the House Condition Survey (HCS) and other research. N/A means not applicable.

Intervention	Proportion of buildings considered eligible for intervention				Reference
	Owner occupied	District owned	Private rented	Commercial	
Cavity wall insulation	28%	21%	39%	28%	HCS indicated proportion of buildings with existing installation and age of buildings. The type of insulation building is eligible for is inferred from age of buildings and lack of insulation.
Solid wall insulation	3.9%	0.3%	1.2%	72%	
Domestic loft insulation	47%	44%	45%	N/A	Remainder inferred from HCS
Domestic floor insulation	29%	31%	33%	N/A	Remainder inferred from HCS
Domestic triple glazing	12%	6%	15%	N/A	Assumed to be eligible for buildings without double glazed windows.
DHW saving measures	100%	100%	100%	100%	No data available, assumed that all buildings could see further improvements under these interventions.
Lighting efficiency	100%	100%	100%	100%	
Appliance efficiency	100%	100%	100%	100%	
Non-domestic high efficiency glazing solar shading	N/A	N/A	N/A	100%	No data available, assumed that all buildings could see further improvements under these interventions.
Heat pumps	95%	95%	95%	100%	No data available, assumed that almost all buildings could see further improvements under these interventions.
Building energy operation	95%	95%	95%	75%	No data available, assumed that almost all buildings could see further improvements under these interventions.

For each of the intervention measures, the EERs anticipated to be affected has been identified. These are shown in Table 18. In our modelling this information is used to refine the number of buildings an intervention is applied to.

Table 18: The EERs impacted by each of the modelled intervention measures.

Intervention	EERs affected
Cavity wall insulation	D - G
Solid wall insulation	D - G
Domestic loft insulation	D - G
Domestic floor insulation	C - D
Domestic triple glazing	C - G
DHW saving measures	C - G
Lighting efficiency	C - G
Appliance efficiency	C - G
Non-domestic high efficiency glazing solar shading	D - G
Heat pumps	A - D
Building energy operation	C - G

4.5 Results and findings

4.5.1 Interventions and retrofits

Impact of policy levers

Figure 22 and Figure 23 show the deployment of policy levers for domestic and non-domestic buildings, respectively, for the High Intervention scenario.

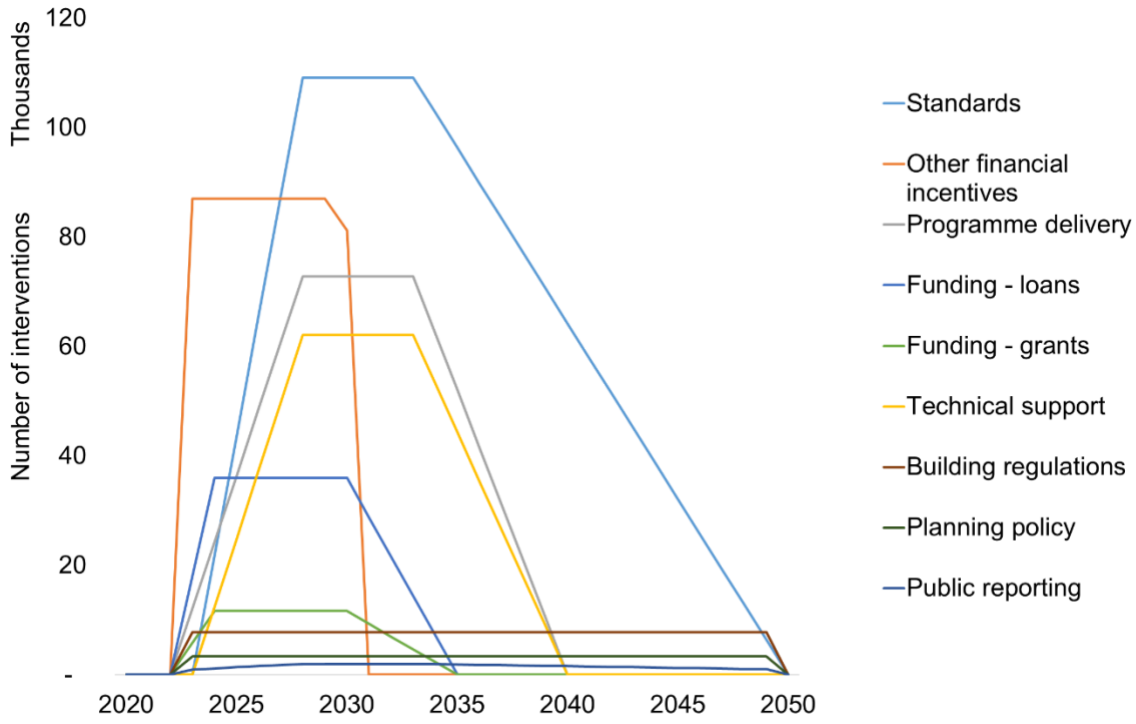


Figure 22: Number of retrofit interventions in domestic buildings for each policy lever. Note that policy levers are listed in the legend by order of peak interventions for readability.

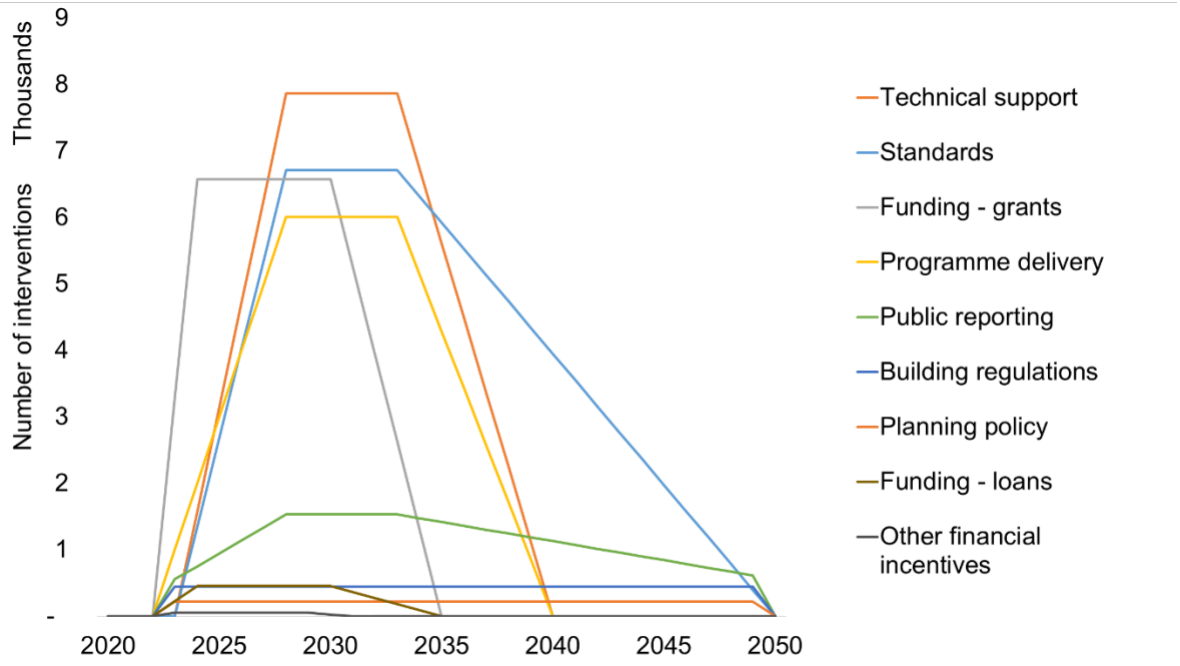


Figure 23: Number of retrofit interventions in non-domestic buildings for each policy lever. Note that policy levers are listed in the legend by order of peak interventions for readability.

From these two graphs it is clear that the Standards policy lever is an important and cross-cutting lever for both domestic and non-domestic buildings, with the greatest peak interventions for domestic properties and second largest for non-domestic. By its nature, the Standards policy lever requires compliance across all building groups and has the highest Reach factor to reflect this. For non-domestic buildings, Technical Support has a slightly higher number of peak interventions, however the deployment of this policy lever has a much shorter timescale and the total interventions (indicated here by the area under each curve) is lower as a result.

When thinking about policy recommendations and shaping policy implementation, it is important to note what drives these results. As discussed, these results suggest that the Standards policy lever is influential and effective however this is driven by the nature of the policy and the assumptions made regarding its impact and application. A main conclusion to draw from this would be that the most influential policy levers are those which target as wide a building stock group as possible and result in the implementation of several intervention measures. In practice, policies should focus on maximising Reach and Effectiveness and give careful considering to deployment shaping.

For domestic buildings, Public Reporting is amongst the least influential policy levers. This is because only Social Housing and District Owned building stock is anticipated to be affected by this lever, which represents only 16% of the total domestic building stock.

The Other Financial Incentives policy lever has the second highest intervention peak for domestic building but is the least impactful for non-domestic buildings. This is because this lever is assumed to apply to all existing Able to Pay domestic building groups but only Large Enterprises for existing non-domestic buildings, which is assumed to comprise less than 1% of the total non-domestic building stock.

Number of intervention measures

Figure 24 and Figure 25 show the deployment of intervention measures for domestic and non-domestic buildings, respectively, for the High Intervention scenario.

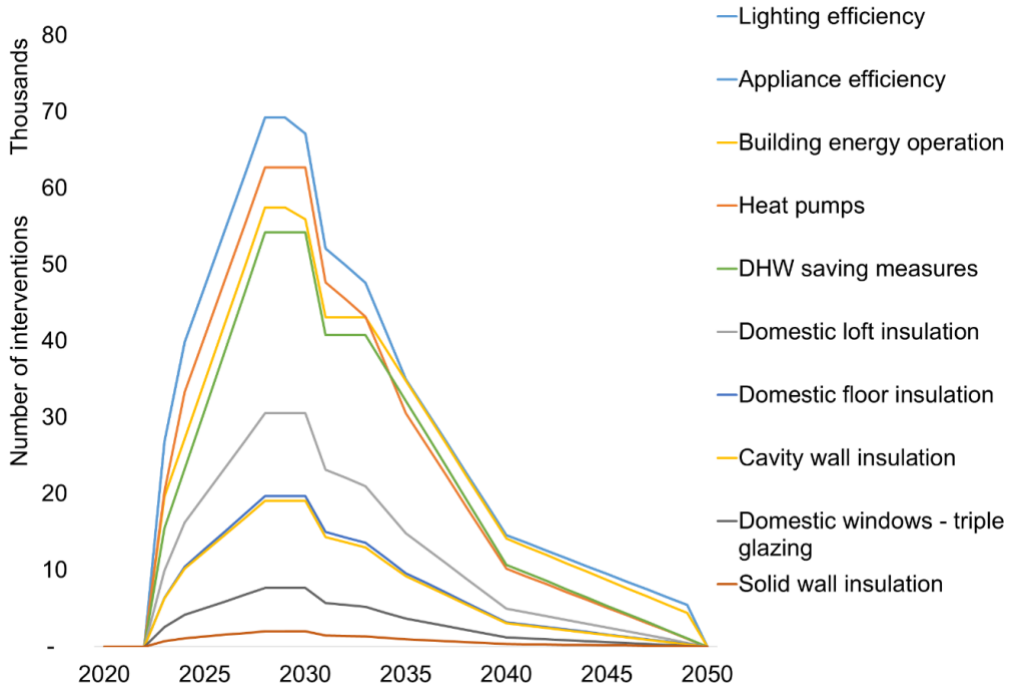


Figure 24: Number of retrofit interventions in domestic buildings for each intervention measure. Note that the deployment of Lighting Efficiency and Appliance Efficiency is identical since these are assumed applicable under the same conditions. Interventions are listed in the legend by order of highest to lowest peak impact for readability.

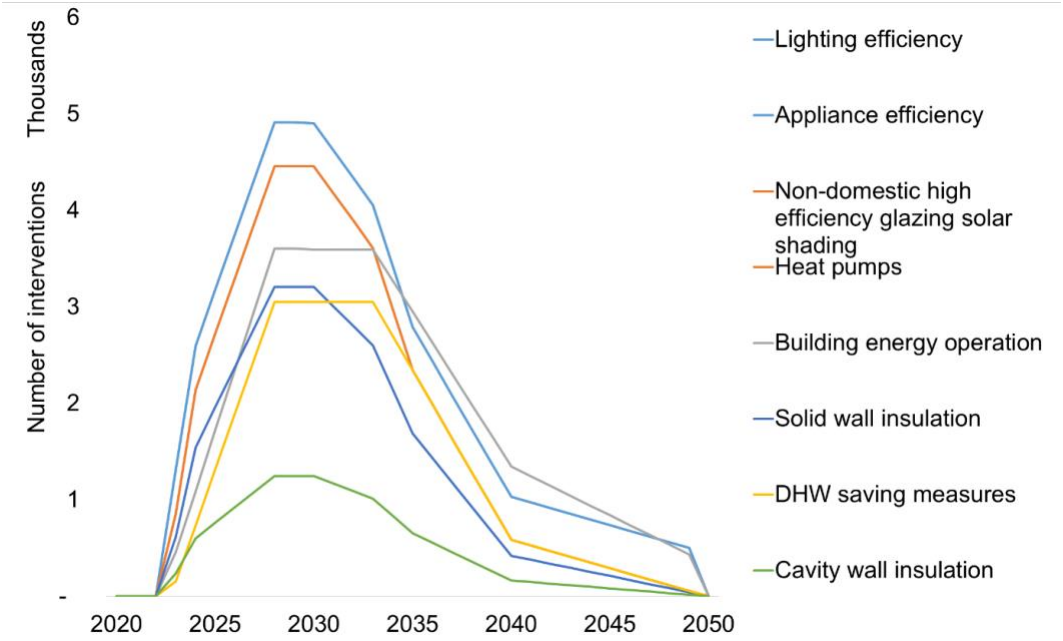


Figure 25: Number of retrofit interventions in non-domestic buildings for each intervention measure. Note that the deployment profiles of Lighting Efficiency and Appliance Efficiency as well as Non-domestic high efficiency solar glazing and Heat Pumps are respectively identical since these are assumed applicable under the same conditions. Interventions are listed in the legend by order of highest to lowest peak impact for readability.

As shown in both of these graphs, interventions for both groups are led by Lighting and Appliance Efficiency, with Heat Pumps also as a leading contributor (with the installation of heat pumps also being dependent on heat policy decisions). Despite the fact that it is likely some buildings already have Lighting or Appliance Efficiency, it has been assumed that 100% of buildings would still be eligible to some extent for these interventions, and that almost all policy levers would include these interventions.

The least deployed measures in domestic buildings are Domestic Windows Triple Glazing and Solid Wall Insulation. As shown in Table 17, these interventions have the lowest of all the eligibility figures. For Solid Wall Insulation, this owes to the fact that many buildings already have some form of insulation installed as well as the fact that the majority of modern buildings have cavity walls rather than solid walls, and so it has been assumed that Solid Wall Insulation would not be applicable in these cases. The House Condition Survey also indicated that many domestic buildings in NI already have double glazed windows, which limits the eligibility of buildings for triple glazing.

A smaller group of intervention measures is available to non-domestic buildings since many others are specific to domestic buildings only. Most of the measures have comparable deployment for non-domestic buildings with the exception of Cavity Wall Insulation which sees significantly fewer interventions. With reference to Table 17, Cavity Wall Insulation was found to be eligible in only 28% of non-domestic buildings which drives this lower number.

For comparison, the RoI Climate Action Plan (Dept. Communications, Climate Action & Environment, 2019) identified a target to install 600,000 homes with heat pumps by 2030, which comprises around 30% of the total domestic building stock. The results of the High Intervention scenario indicate just under 386,000 heat pumps installed in homes under the same timescales, which comprises a higher installation rate of around 48% in NI.

Number of buildings

Figure 26 and Figure 27 show the total number of domestic and non-domestic buildings which undergo some form of retrofit each year for each of the three scenarios. The figures shown in these graphs account for the fact that each building may have up to 10 interventions applied, but the numbers of buildings in the figures include each building only once.

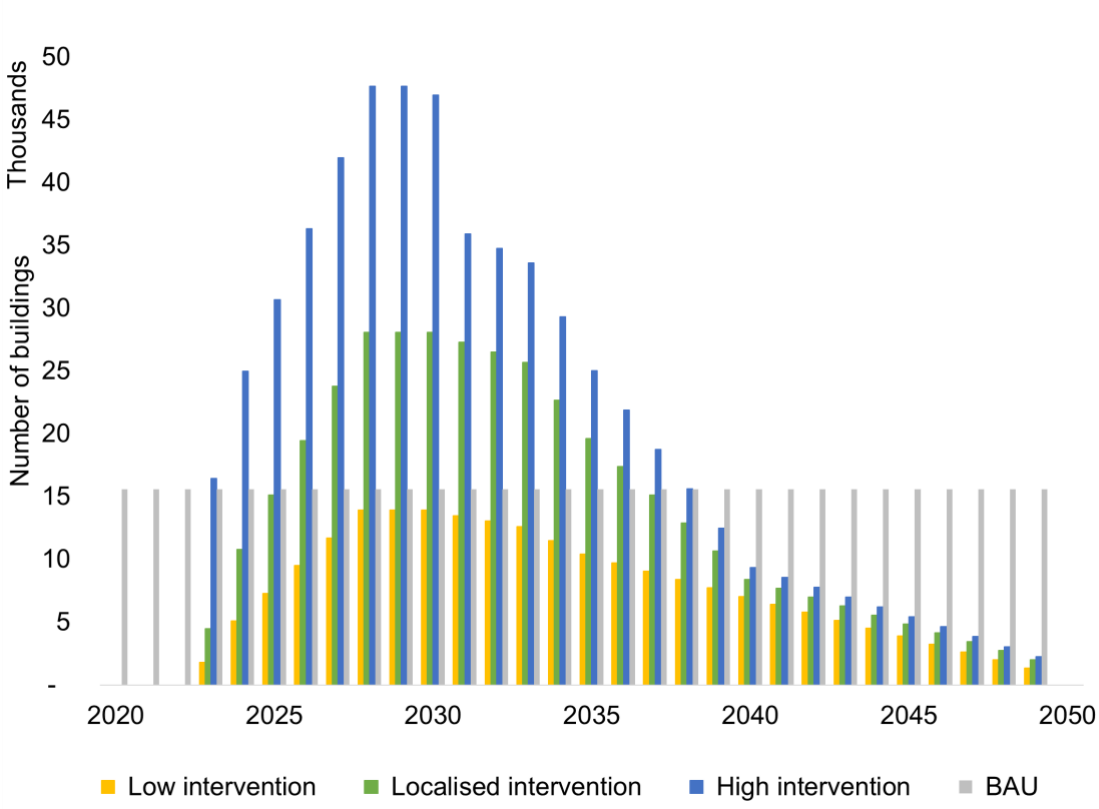


Figure 26: Annual domestic building retrofits for each of the three modelled scenarios and an estimate of the BAU.

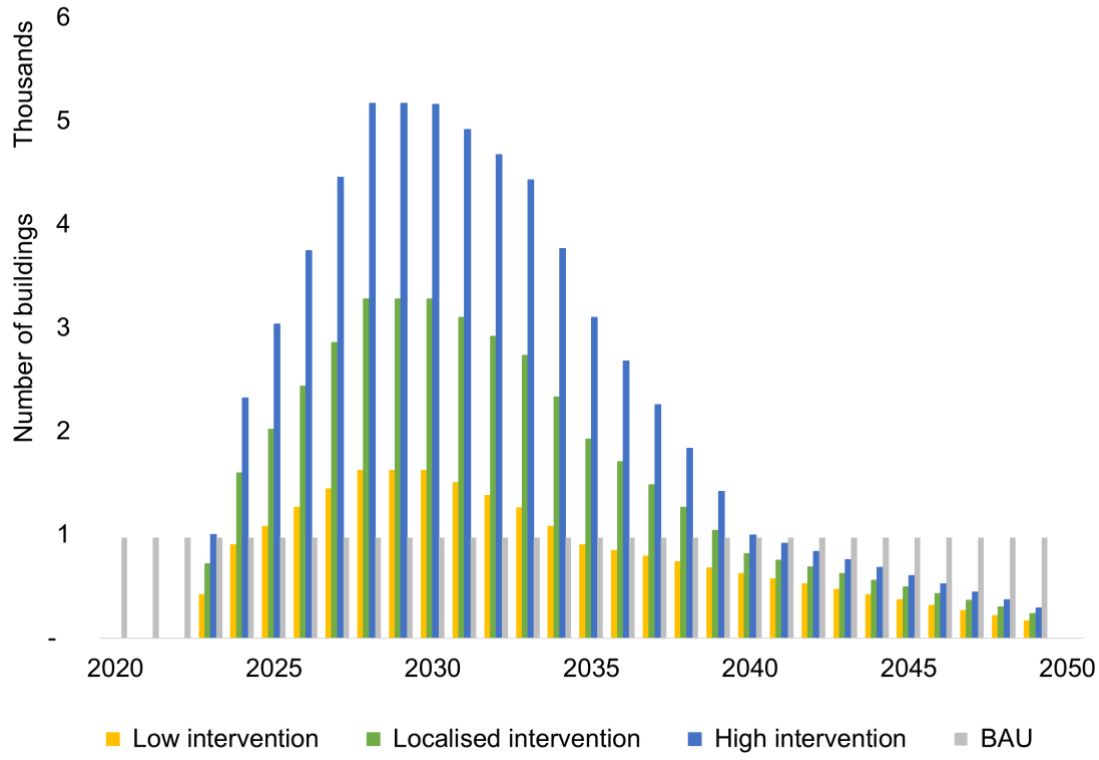


Figure 27: Annual non-domestic building retrofits for each of the three modelled scenarios and an estimate of the BAU.

These graphs show how the interventions resulting from the policy levers and intervention measures come together to impact individual buildings. The shapes of these graphs are driven by the policy deployment shapes defined in Table 16, resulting in peak deployment of circa 53,000 buildings, for domestic and non-domestic combined for the High scenario. This occurs in 2030, when many policy levers have uniform deployment.

For comparison:

- Under NISEP, 65,000 homes benefitted between 2010 and 2017 (Utility Regulator, 2019), therefore approximately 9,300 homes per year. However, we understand from DfE that some of homes had multiple interventions so could be counted multiple times in these numbers.
- Under the Affordable Warmth Scheme, 4,148 homes were improved in 2017/18 (Energy Saving Trust, 2019).
- Under the Boiler Replacement scheme, there were 3,061 upgrades in 2017/18 (NIHE, 2018).
- The Warm Homes Scheme assisted 120,000 households between 2001 and 2015 (Bryson Energy, 2015), therefore approximately 8,600 homes per year.

The total number of buildings upgraded by the current schemes (the first three above, excluding Warm Homes) is approximately 16,500 buildings per year. Therefore, the results shown for the High scenario of circa 53,000 buildings suggest a greater requirement for building upgrades under all of the modelled scenarios.

Figure 28 and Figure 29 show the cumulative domestic and non-domestic buildings retrofitted under each of the scenarios. As for the previous figures, a building can be modelled to require multiple interventions, but the numbers include each building only once.

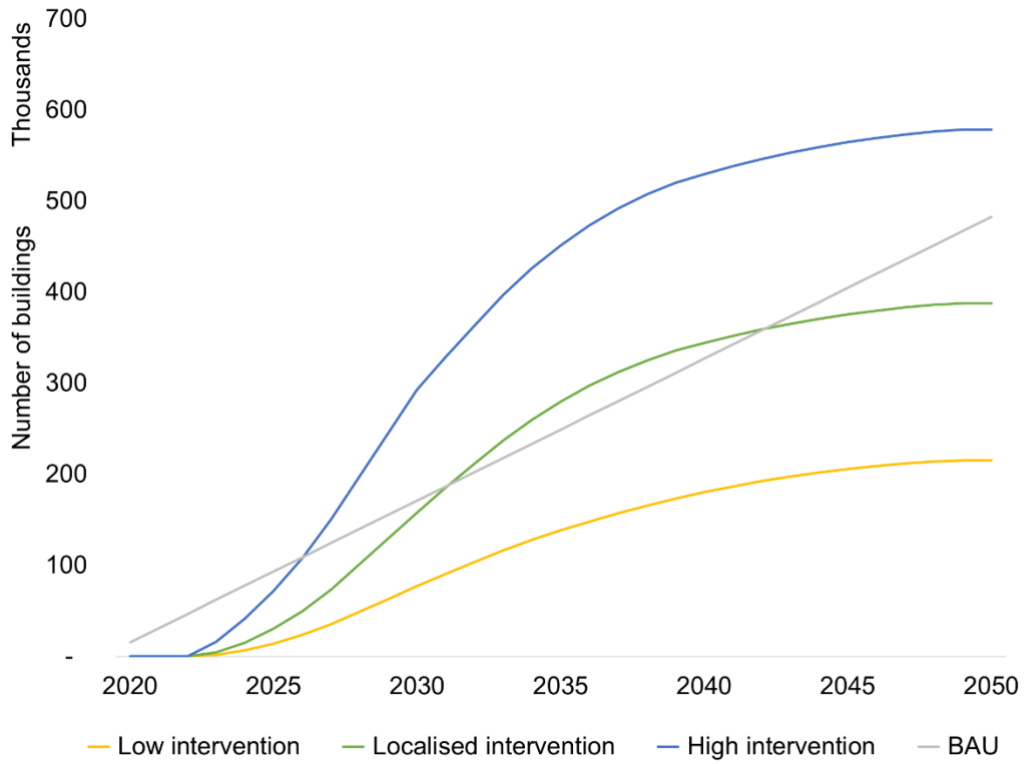


Figure 28: Cumulative domestic building retrofitted for each of the three modelled scenarios. An estimate for the BAU is presented for comparison, based on continued implementation in line with historic figures.

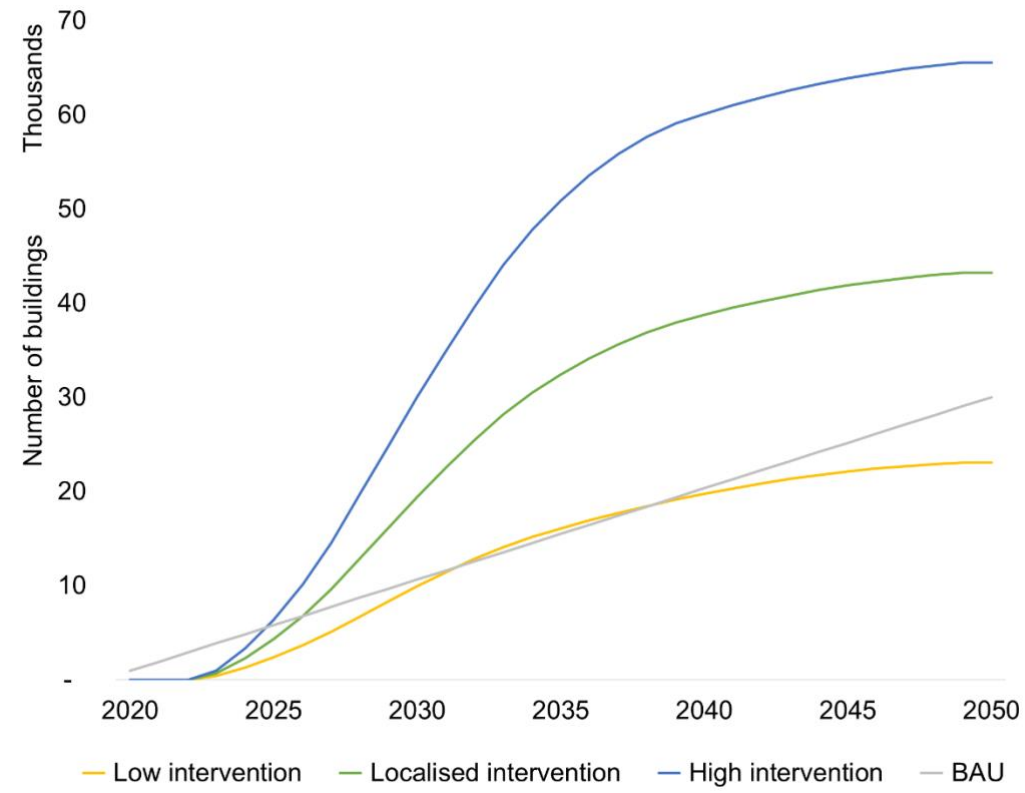


Figure 29: Cumulative non-domestic building retrofitted for each of the three modelled scenarios. An estimate for the BAU is presented for comparison, based on continued implementation in line with historic figures.

These graphs demonstrate how over time a typical S-curve of intervention uptake results from the deployment of the policy levers. Both graphs begin around 2023 with a sustained acceleration of building retrofits until around 2030, which is when some deployment shapes begin tapering off resulting in a deceleration towards a plateau close to 2050.

There are approximately 799,000 domestic (Department for Communities, 2019) and 73,000 non-domestic buildings (Delorme & Neely, 2016) in NI. Under the High Intervention scenario, 571,000 and 67,000 domestic and non-domestic buildings are retrofitted respectively, representing 71% and 91% of the total stock. Under the Low Intervention scenario this is significantly lower, at around 27% and 32% of the domestic and non-domestic building stock respectively.

4.5.2 Costs and benefits

In this section, we provide high-level estimates of costs to assist DfE with their next stages of analysis. As such, care should be taken to verify the assumptions used. The total investment costs required for the intervention measures described in the preceding sections were calculated using cost data collected from suppliers and the Energy Savings Trust (2020)[18]. Figure 30 and Figure 31 show the total cost requirement annually for domestic and non-domestic buildings. These graphs have strong correlation with Figure 26 and Figure 27 which show total building retrofits.

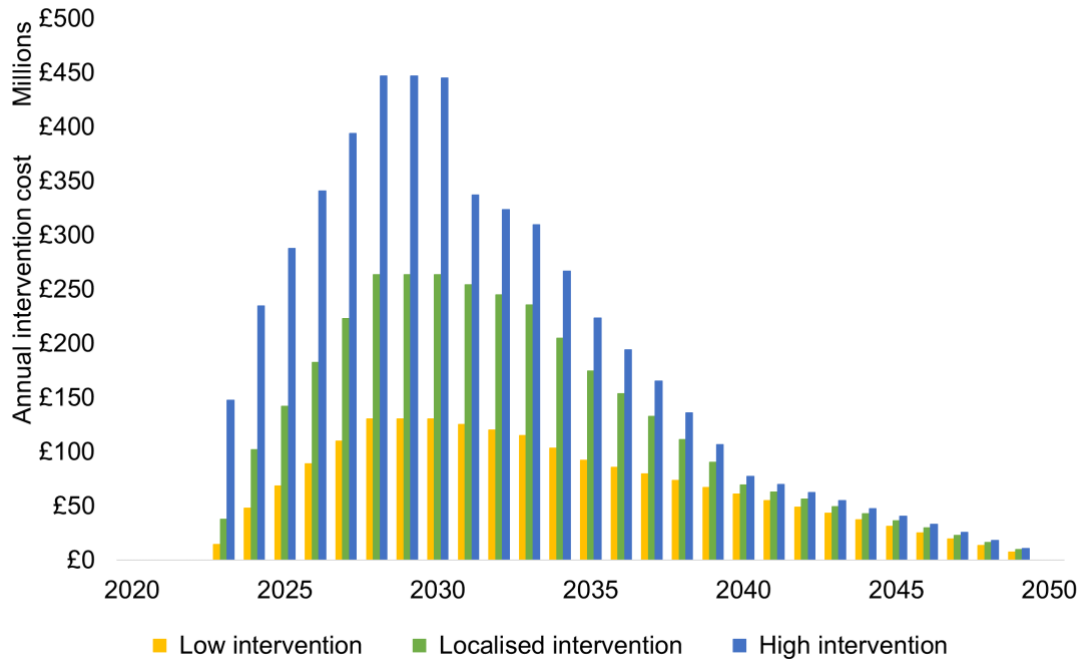


Figure 30: Total annual cost of interventions in domestic buildings for each of the three modelled scenarios.

[18] Publicly available cost data from EST is provided as UK averages. We recognise that in some instances, due to variations in regulations and supply chains, costs are likely to be higher in Northern Ireland. As such, we recommend that regional variations are considered in advance of policy implementation.

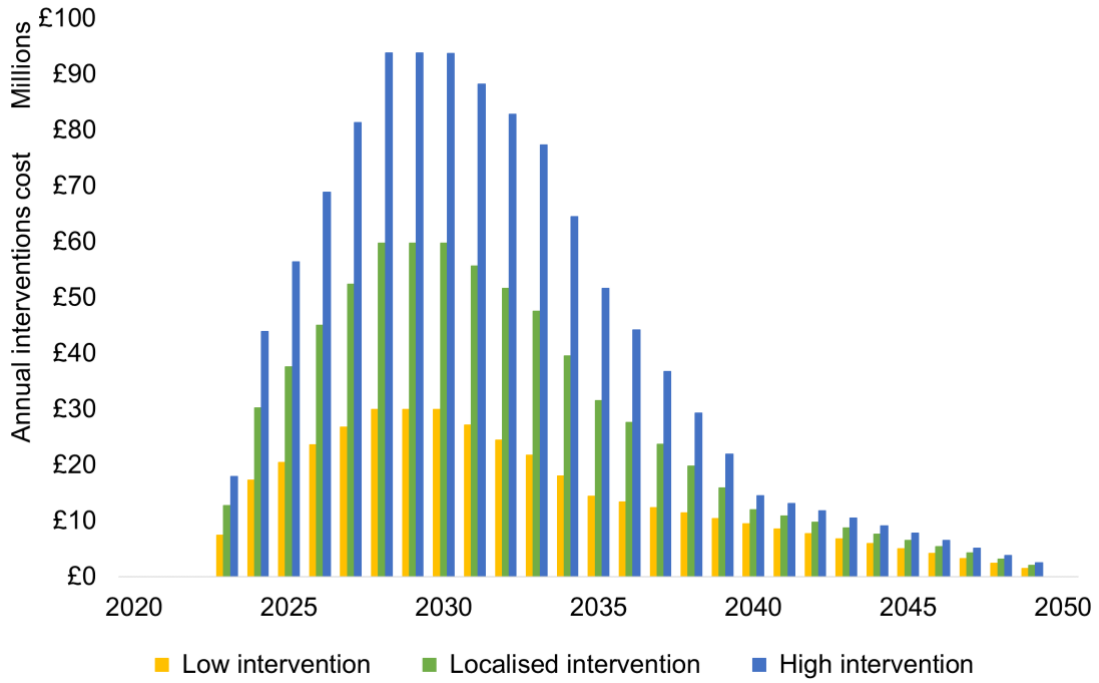


Figure 31: Total annual cost of interventions in non-domestic buildings for each of the three modelled scenarios.

Figure 32 and Figure 33 show the costs for High intervention scenario disaggregated by the types of measures, for domestic and non-domestic buildings, respectively. Low temperature heating systems (predominantly heat pumps) are the largest single contributor to the costs with an estimated £3.6 billion investment in total from 2023 to 2049. The assumptions used are provided in Appendix G.

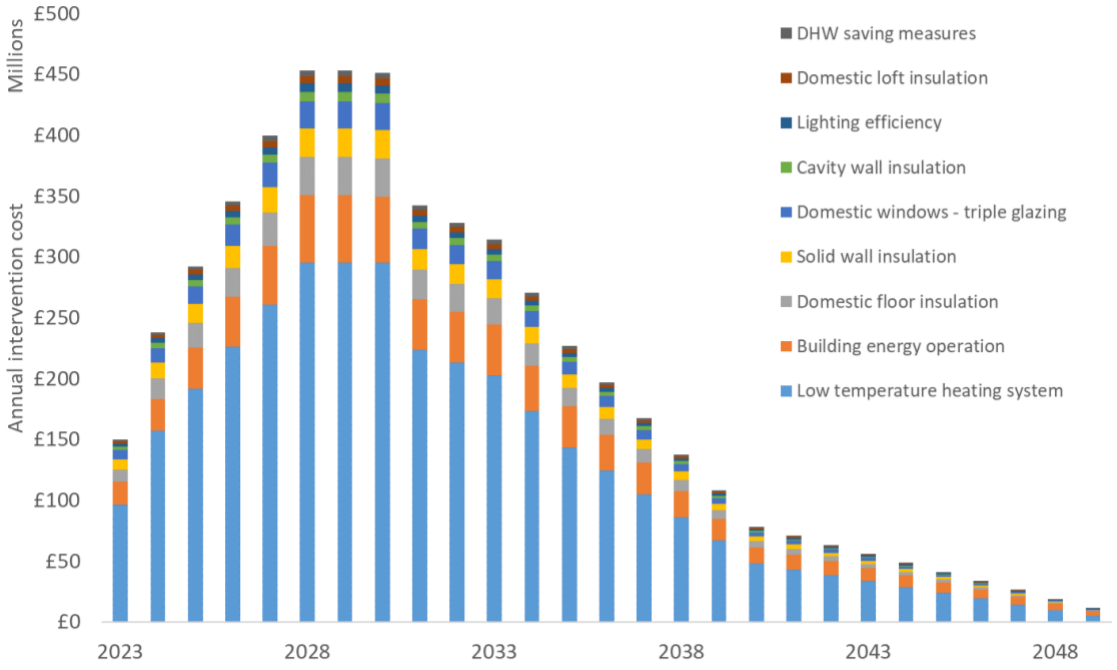


Figure 32: Total annual cost of interventions for domestic buildings for the High scenario.

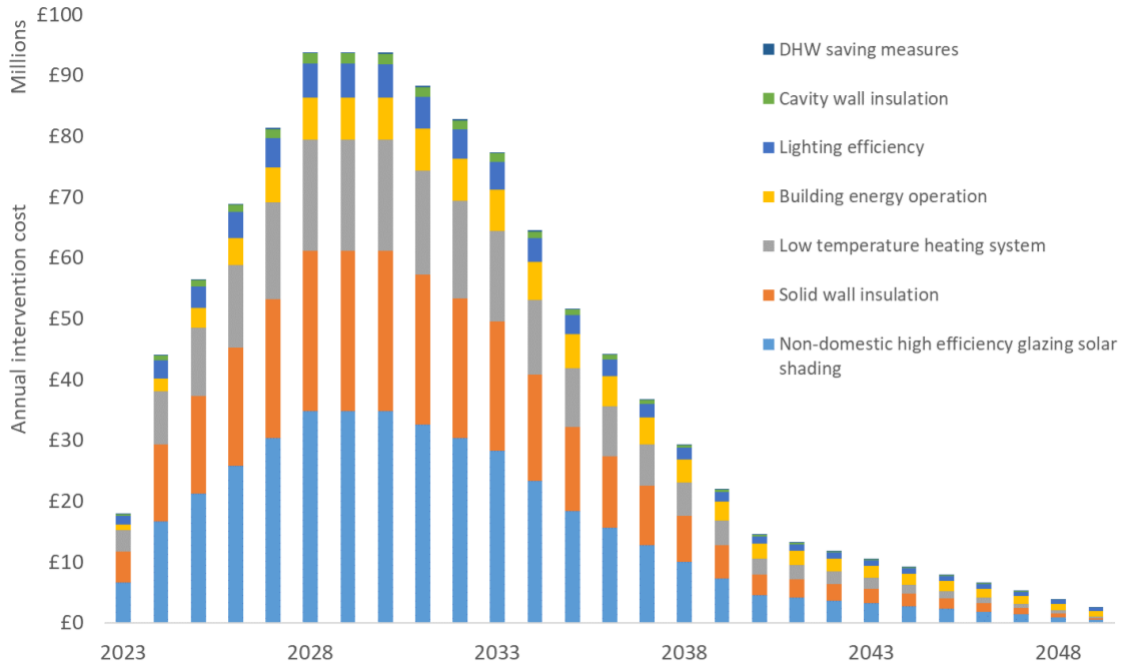


Figure 33: Total annual cost of interventions for non-domestic buildings for the High scenario.

A 2017 report by the UK Green Building Council (2017) found that for every £1 million of investment in energy efficiency retrofits, approximately 23 person-years of employment would be created. Figure 34 shows the total annual jobs created through retrofit across domestic and non-domestic buildings. The graph shows that using this assumption, at its peak under the High Intervention scenario, around 12,000 person-years of employment would be created per year.

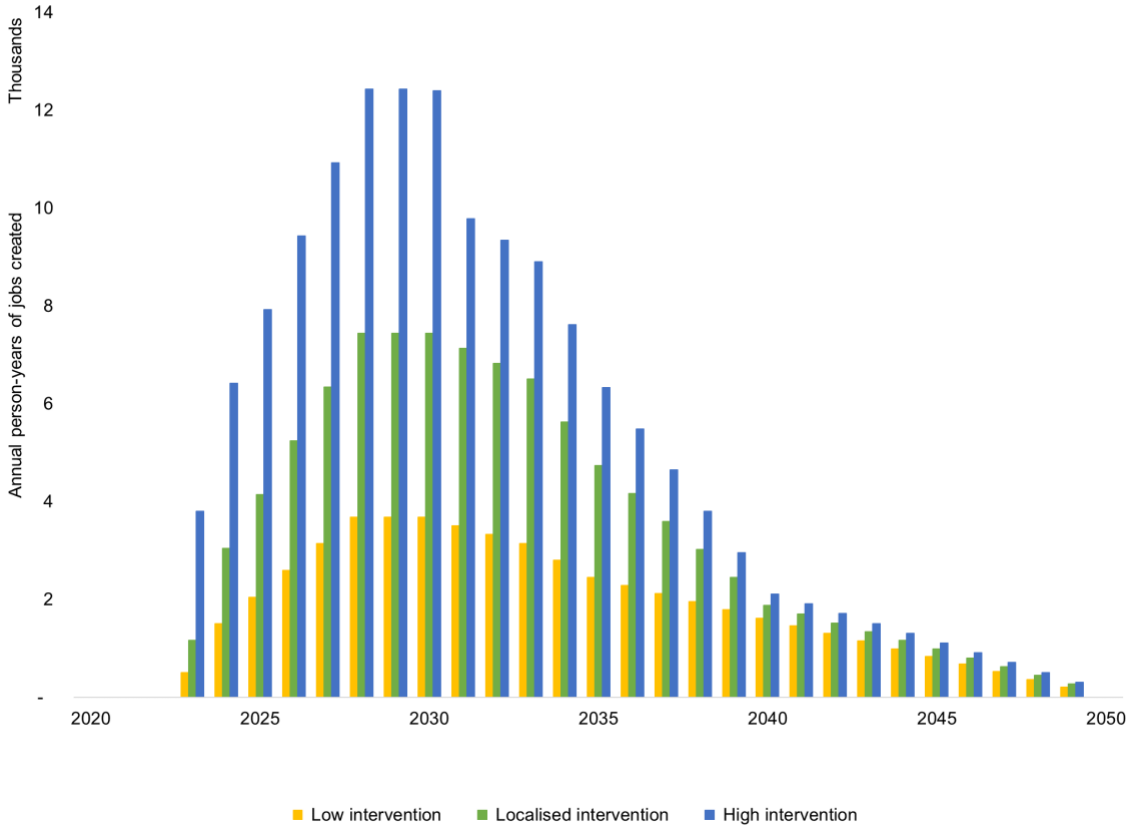


Figure 34: Total annual person-years of employment created through intervention installations

As noted in section 2.7, there are a number of other co-benefits to energy efficiency , and these are not considered in the above analysis.

4.5.3 Energy demand reduction

Figure 35 and Figure 36 show the energy demand savings arising from each of the modelled policy levers for domestic and non-domestic buildings. These savings have been derived using estimates of energy savings for measures, combined with the applicable policy levers, reach factors, and effectiveness factors, described earlier. Results are shown here for the High Intervention scenario.

Both graphs show that Technical Support, Standards and Programme Delivery are important policy levers delivering the largest reductions in energy demand. These levers were also dominant in the deployment graphs shown above, although the results shown here are also driven by the fact that these levers are amongst some of the only ones which map against all intervention measures. Other Financial Incentives also maps against all intervention measures, however this policy lever affects a much smaller proportion of building stock and so has less of an overall impact.

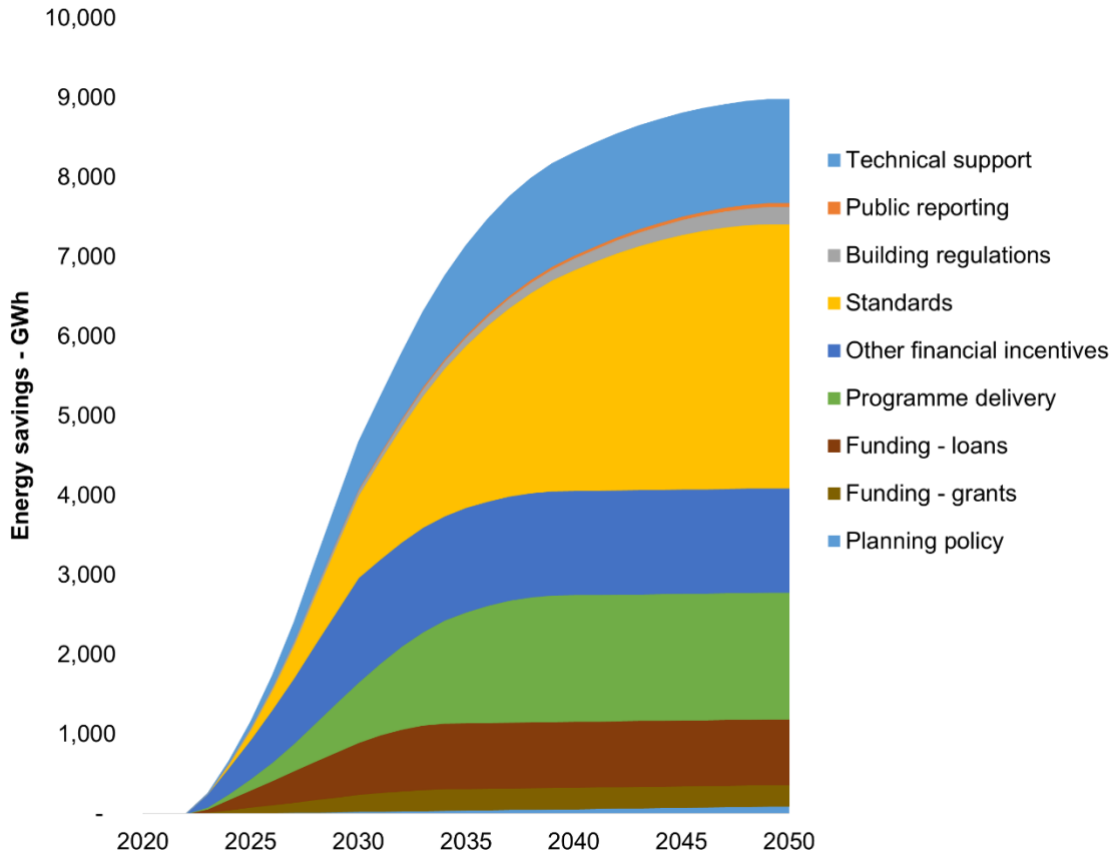


Figure 35: Energy demand savings in domestic buildings from each of the modelled policy levers.

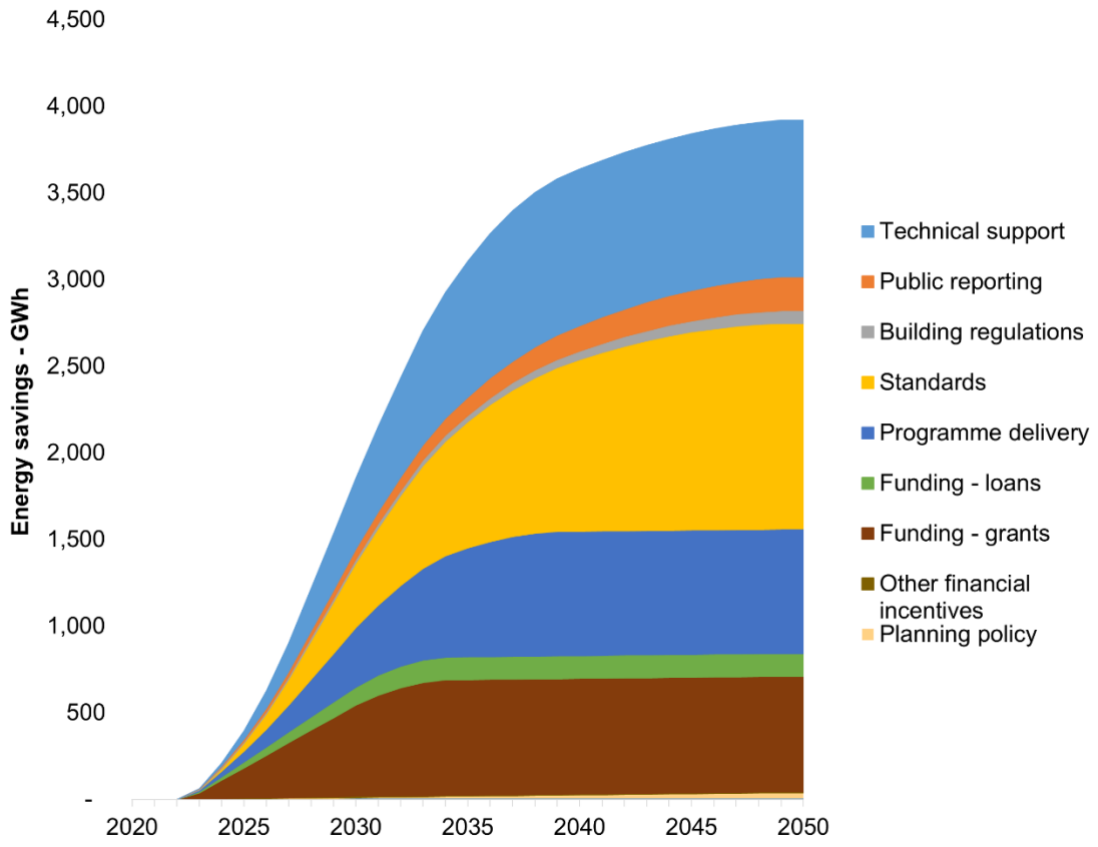


Figure 36: Energy demand savings in non-domestic buildings from each of the modelled policy levers.

Following on from the energy savings by policy lever presented above, Figure 37 and Figure 38 present the energy demand trajectories, for domestic and non-domestic buildings respectively, across the modelled scenarios.

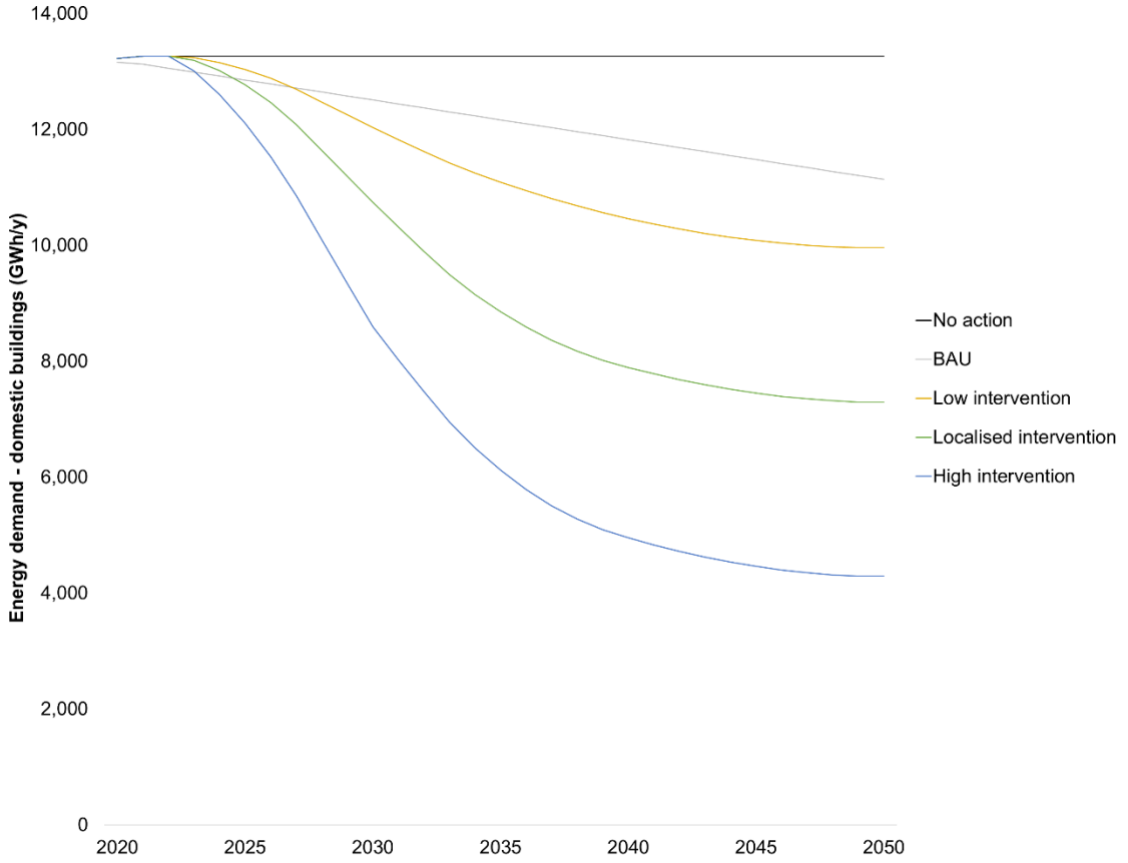


Figure 37: Modelled energy demand trajectories for domestic buildings

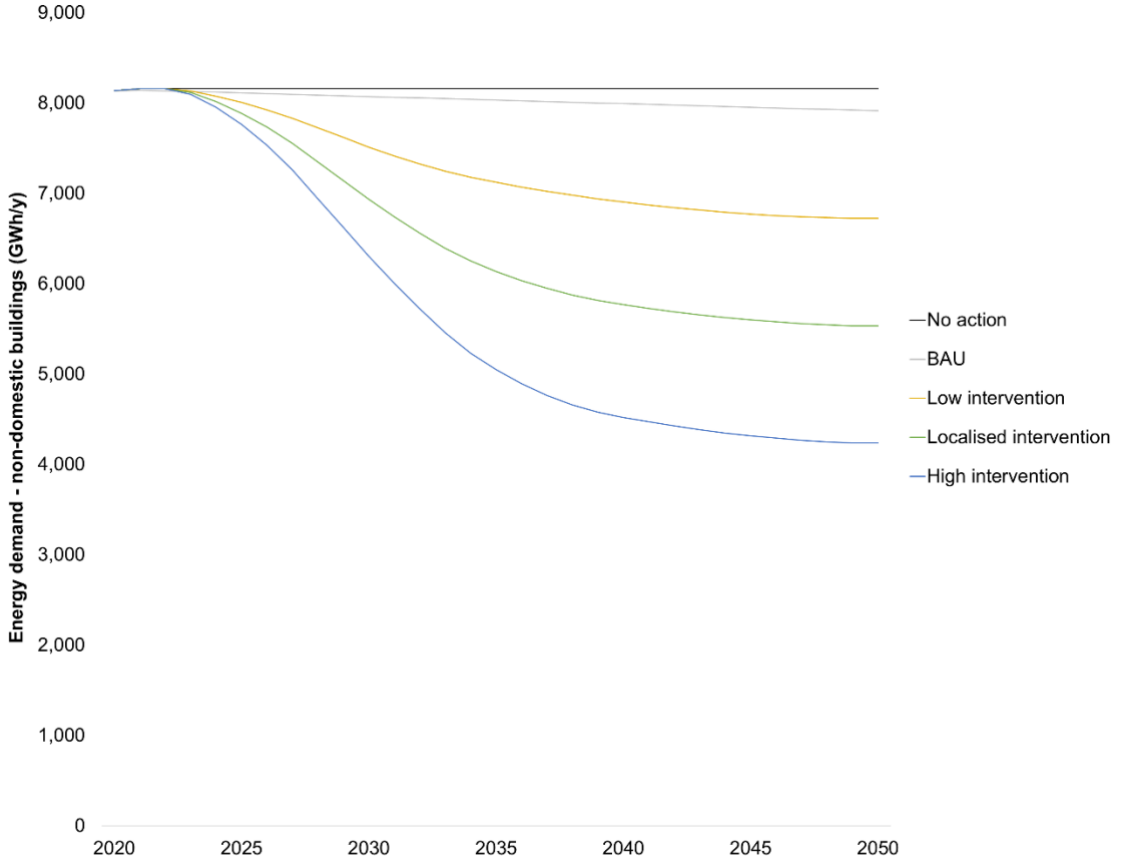


Figure 38: Modelled energy demand trajectories for non-domestic buildings

Figure 39 shows a comparison between the energy demand reduction achieved in the modelled scenarios and other contextual trajectories including the FES (National Grid, 2019). Although the modelling and results shown here are in the context of energy demand, comparison against the FES and CCC targets gives an indication of the implications for carbon emissions, since these scenarios include projections for the contributions that energy efficiency can provide for carbon reduction pathways. However, it should be noted that the most ambitious FES scenarios – Two Degrees and Community Renewables – only achieve an 80% reduction in carbon emissions by 2050, not net zero emissions.

Due to the steady increase in the number of buildings in NI as new properties are built, the 'No action' scenario shows a very slight steady increase above 100% from 2020 onwards, comparable to the Steady Progression scenario modelled by the National Grid in FES, which represents minimal intervention.

The BAU scenario, which includes current NI policies continuing on to 2050, achieves a final reduction of 9.2% in energy demand, which is almost identical to the FES Consumer Evolution scenario despite the fact that between 2020 and 2050, these two lines have very different trajectories.

The Low Intervention scenario achieves an overall reduction of 20% by 2050. This trajectory does not meet the UK's 2030 demand target (CCC, 2019c).

The Localised Intervention scenario achieves a 15% reduction in demand by 2030, which exceeds the UK's target by 1%. By 2050 this scenario sees a total reduction of 36%. Despite the fact that this scenario meets the 2030 target, the endpoint of this trajectory in 2050 does not achieve the same progress as the two most ambitious FES trajectories, which in themselves only achieve an 80% reduction of carbon emissions (National Grid, 2019). For this reason, it is not enough to only compare progress against the 2030 target.

In contrast, the High Intervention scenario achieves a 55% reduction in energy demand by 2050, which exceeds the two most ambitious FES scenarios Community Renewables and Two Degrees by 12% and 10% respectively. This scenario also surpasses the UK's 2030 demand target by 13%, achieving a 27% demand reduction compared against 2020 energy demand.

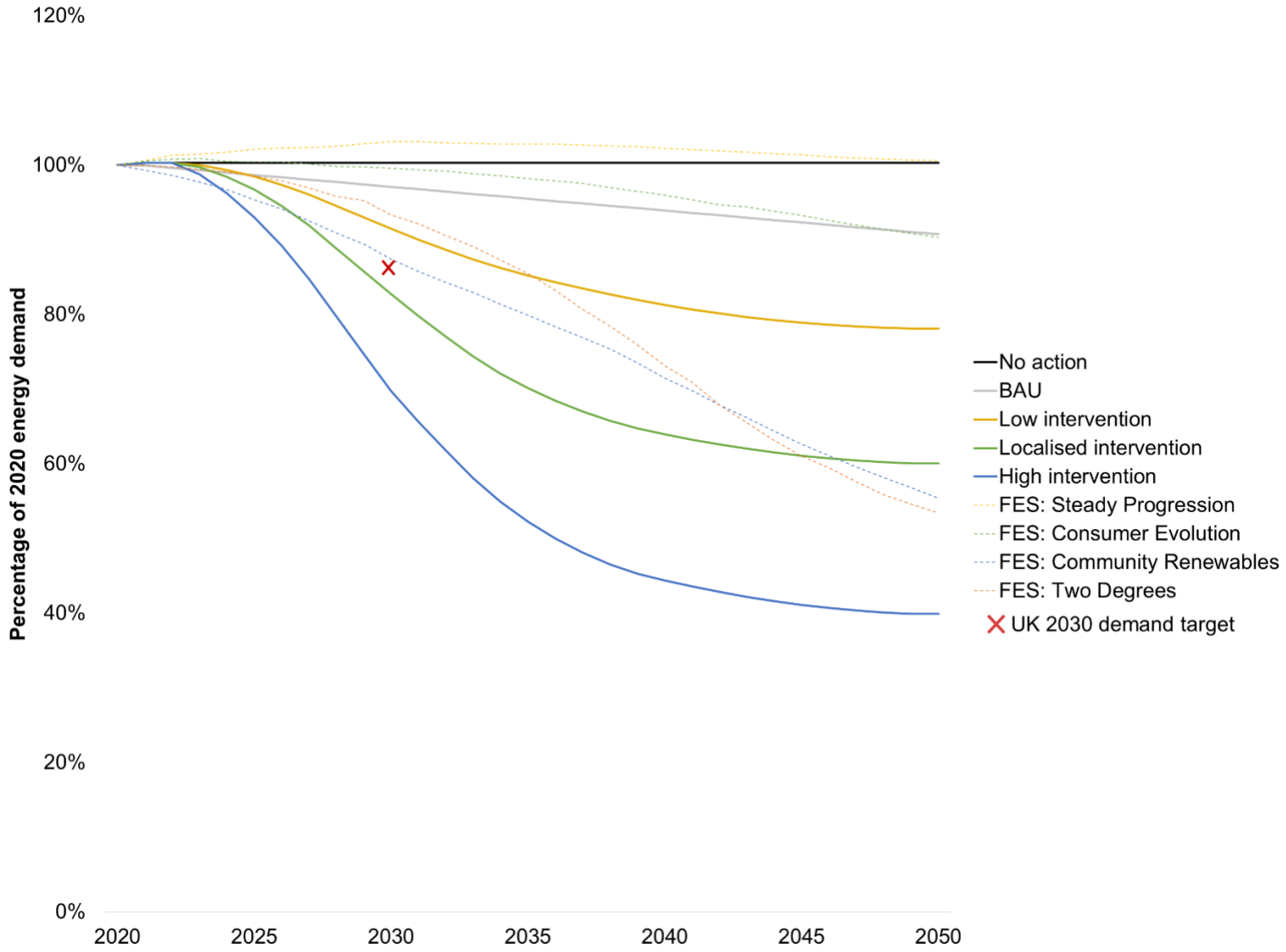


Figure 39: Modelled energy demand trajectories compared against the No Action & BAU scenarios for NI as well as the four National Grid FES 2019 trajectories (National Grid, 2019). Also plotted is the 2030 energy demand reduction target for the UK as specified by the Net Zero technical report (CCC, 2019c).

For the High scenario modelled in this study, an average of circa 21,000 homes per year need to be upgraded over 27 years, equivalent to 71% of the housing stock. For comparison, there are 1.3 million homes in Wales and it is thought that in order to meet 2050 targets, Wales needs to retrofit all homes, equating to 40,000 homes per year until 2050 (National Assembly for Wales, 2018). Both the Welsh and NI dwelling stock have a mean average Standard Assessment Procedure (SAP) energy rating of 61 points, equivalent to an EER of D. The profile of the EERs are also similar, illustrated below.

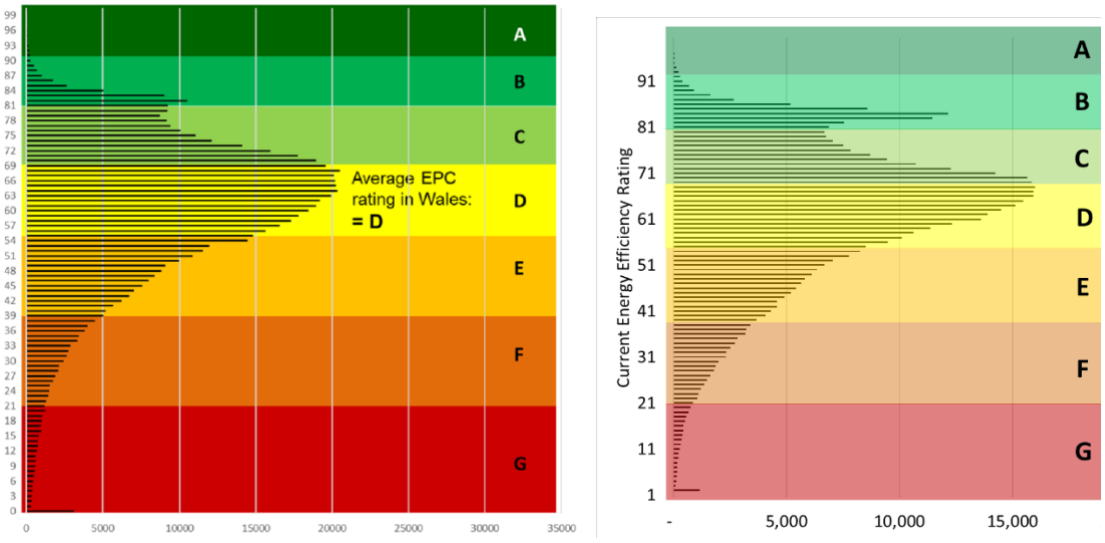


Figure 40: Comparison of EER profiles for Wales (left; Decarbonisation of Homes in Wales Advisory Group (2019)) and NI (right; Arup analysis created from data supplied by Department of Finance (2020)). Horizontal axis is number of homes (label excluded from figures for clarity of comparison).

The table below presents key metrics from the results of modelling the scenarios.

Table 19: Key metrics from the scenario modelling

	BAU	Low Intervention	Localised Intervention	High Intervention
Annual energy demand savings by 2050 (GWh/y)	1,977	4,682	8,535	12,837
Cumulative number of buildings retrofitted to 2050	513,000	238,000	431,000	644,000
Estimated total costs of interventions to 2050	Data not provided	£2.3 billion	£4.3 billion	£6.5 billion

5 Analysis

This chapter provides analysis and discussion on key cross-cutting issues that extend across the range of policy levers and scenarios that we have considered.

5.1 Roles and responsibilities

The roles and skills required to deliver each of the policy levers that we have explored in this report are set out in the table below. In this, we set out who could hold each role in NI, given our understanding of current remits. Those highlighted in italics could become part of a potential one-stop shop described in Section 5.5.

Table 20: Roles and skills required to deliver the policy levers

Policy lever	Roles	Skills required	Options for holding this role in NI
Funding – grants	*Administering funding schemes*	*Energy / building engineers, economists, planners, customer relations, public engagement experts, finance managers, project / programme managers*	*Various – new body; Local councils; NI Government departments*
Funding – loans	*Administering funding schemes*	*Energy / building engineers, economists, planners, customer relations, public engagement experts, finance managers, project / programme managers*	*Various – new body; Local councils; NI Government departments; Energy supply companies*
Programme delivery	Carrying out works on individual buildings *Providing support / training / accreditation to contractors / suppliers of energy efficiency services*	Energy / building engineers, electricians, plumbers, builders, project / programme managers *Energy engineers, training specialists, project / programme managers*	Procured by NI Government departments for public sector buildings / individual building owners *Various – new body; Local councils; NI Government departments; Energy supply companies*
Other financial incentives	Providing tax incentives through rates Providing incentives through business rates Providing incentives through VAT holiday	Revenue collection, tax specialists,	Local councils NI Government departments
Standards such as Minimum EE standards and EU appliance standards.	Setting standards	Energy / building engineers	NI Government departments NI Utility Regulator

Policy lever	Roles	Skills required	Options for holding this role in NI
Building regulations	Setting building regulations	Energy / building engineers	NI Government departments NI local councils (regarding enforcement)
Planning policy	Setting planning policy	Planners, energy / building engineers	Local councils
Public reporting	*Collecting data on energy performance* *Reporting data on energy performance*	*Data scientists, data visualisation specialists, public engagement experts*	*Various – new body; Local councils; NI Government departments; Energy supply companies*
Technical support	*Providing technical advice and assistance to the domestic and non-domestic sectors*	*Energy / building engineers, planners, customer relations, project / programme management*	*Various – new body; Local councils; NI Government departments; Energy supply companies*
Communications and engagement	*Promoting energy efficiency to domestic and non-domestic sectors*	*Public engagement experts, communications specialists,*	*Various – new body; Local councils; NI Government departments; Energy supply companies*

5.2 Funding and financing

It was highlighted through stakeholder engagement that it is difficult to secure long-term funding required for more prolonged programmes of investments. For example, the one-year investment cycle of NISEP does not facilitate longer rollouts of energy efficiency measures, which constrains the investment which the supply chain is willing to make to increase its capacity. If programme funding cycles were extended, suppliers could invest in capacity with more confidence of a sustained market to service.

UK examples of home retrofits at a much larger scale are:

- Nest and Arbed in Wales (section A4.4.1 and A4.4.2, respectively); and
- Warmworks in Scotland (Warmer Homes Scotland, Section A4.3.1) (Patterson, 2012).

These schemes target the ‘unable to fund market’ (sometimes referred to as the fuel poverty market) with *consistent* funding, normally likely to be required in the form of grants. It is important to note that whilst these schemes may have ambitions to take a whole house approach to home retrofits, they are often restricted by available funding. Moreover, they are motivated to address fuel poverty, not explicitly to address energy efficiency (albeit the two are closely related). This is important when thinking about the success measures of a scheme. In any case, the key success factor for these schemes appears to have been the application of consistent, sustained funding mechanisms to reduce the financial barriers to home retrofits. Loans can be effective, particularly at below market rate.

Another successful approach is loan-based financing which is repaid through local taxes. The Sustainable Melbourne Fund (SMF) was established by the City of Melbourne Council in 2002 to provide financial support to businesses implementing projects with an environmental benefit. Success of the fund led to national expansion of the programme; in 2019 the fund was renamed ‘Sustainable Australia Fund’, significantly recapitalised and expanded

nationally with a loan facility in excess of $200m (£110m). The fund allows both tenants and property owners of small and medium-sized enterprises (SMEs) to take up 100% finance with repayments through council rates. This enables a business to generate savings to boost its profits through a reduction in energy bills while property owners benefit from capital growth to their building. Loans of up to $500,000 are provided. SMF has made over AUD 16.9 million (£9.3m) in direct investments in building upgrades, renewable energy systems, residential neighbourhood innovations, lighting solutions and software technology (C40, 2016).

The Coalition for the Energy Efficiency of Buildings (CEEB) aims to stimulate action across the finance sector to support the decarbonisation of homes. The CEEB is taking forward 21 financial products and services to overcome some of the barriers faced across building tenures (Green Finance Institute, 2020). The proposals include:

- Building Renovation Passports tool to increase the rate and depth of retrofits, providing information on what measures are possible and a long-term renovation plan that can be achieved at a flexible pace.
- TrustMark 'Call to Action' platform to support customers through the full retrofit journey: identifying improvements, sources of funding and linking homeowners to a reputable supply chain.
- Residential Retrofit Principles. An industry-recognised certification for financial solutions that support the retrofit of residential buildings to a high standard, to enhance the confidence of lenders and borrowers.
- Sustainable Housing Label. A certification scheme for green buildings and retrofit projects, spanning the full breadth of tenures, to stimulate demand and investment into the sector.
- Green Leases with an 'Energy Alignment Clause' enable landlords to recover the cost of a retrofit, based on the predicted energy savings, and minimise the landlord-tenant split incentive.
- Affordable Rent, Affordable Living. Adjust the 'affordable rent' definition to include modelled energy costs, to incentivise landlords to deliver properties where tenants can afford the combined cost of rent and energy bills.
- Property Assessed Clean Energy 'style' financing. Financial institutions provide long-term capital for retrofit projects, while local authorities or associated independent third parties collect repayments via an additional property charge that is passed through to the lender.
- Green Equity Release. Enables homeowners over the age of 55 to unlock the equity in their property for investment, with favourable terms to incentivise investment into energy efficient improvements.
- Domestic Energy Efficiency Salary Sacrifice Scheme. A salary sacrifice scheme that allows employees to draw a loan through their employer for investment into home energy improvements, which is repaid via gross salary contributions.
- Add-to-my-Mortgage Platform. A digital platform to streamline the process for homeowners to apply for a Further Advance (e.g. additional borrowing on their mortgage) at the 'point of sale' of energy efficiency measures.
- MEES Compliant Funding. An energy performance guarantee that allows private-rental landlords to procure long-term compliance with MEES requirements.

5.3 Communication and engagement strategy

The importance of a communication and engagement strategy for the dissemination of information about funding schemes and appropriate energy efficiency measures for both businesses and households should not be underestimated. Our review has found that the integration of this within the design of the delivery of policy levers has been important elsewhere. This will be particularly true if there are a range of policy levers delivered in tandem.

The effectiveness of a strategy, however, can be dependent upon its focus. Many policy interventions have involved a focus through their communication and marketing on energy saving potential and associated costs, which is based on a presumption that cost is the most important factor, particularly for a household. We have found that there are wider benefits which, if acknowledged by the actors delivering energy efficiency measures, may assist in uptake. A failure of the Green Deal in Great Britain was a narrow focus of engagement with consumers. Further information on this scheme can be found in A4.1.3.

It is understood that any wider communication and engagement strategy regarding a programme of measures would tie into a wider communications strategy for the Energy Strategy.

Community-based social marketing (CBSM) is a method of driving demand (McKensie-Mohr, 2011). Fundamental to CBSM is 'creating the social norm': in this context the norm being having an upgraded house. Initiatives occur at the street or community level and use social influence to change behaviour, for example, the use of trusted referral networks, community champions, green open homes and providing peer learning sessions to homeowners who in turn would become advocates (Atkinson, et al., 2019). Generating word-of-mouth, particularly in the able to fund market, but not excluding unable to fund schemes, is a powerful way to stimulate adoption rates of home upgrades.

An example of CBSM in use is by RetrofitWorks in the Cosy Homes Oxford, Warmer Sussex and other schemes. They run a 'one-stop-shop' type arrangement and use local community groups as advocates for a central delivery model. Cosy Homes marketing materials are distributed to community groups who then modify them to their area, e.g. have their own logos alongside the Cosy Homes brand. If the groups have a clear idea of how to engage customers, they are free to try it out.

Using local communities to advocate on behalf of a scheme is also an important way of levering a trusted brand to deliver a message through already trusted community networks. Advocating at a local level provides an opportunity for a scheme to start small and scale up, giving an element of control in its growth which is important when considering balancing the growth in local supply chain capacity.

The CBSM approach is data driven and relies on research to determine target audiences to develop customised initiatives (Ross Strategic, 2016). For the Manchester Carbon Co-op, this has meant focusing on people, not house types (Atkinson, et al., 2019). They did this by identifying the geographic locations of those who they knew had already commissioned home upgrades (early adopters). They then looked for patterns, developing an understanding of who and where these people tended to live (Atkinson, et al., 2019). This research created a map of target areas and helped create a shortlist of priority neighbourhoods for targeted service delivery.

5.4 Energy efficiency targets

5.4.1 Choosing a metric

There is currently no energy efficiency target for NI, although it contributes to the UK target (derived from the EU EED) which represents an 18% reduction in final energy consumption, relative to the 2007 business as usual projection, by 2020 (DECC, 2014). Our literature review and stakeholder engagement revealed that a target for energy efficiency would place the onus on programmes to explicitly target and monitor energy efficiency, and ultimately, could lead to an increased incentive and drive to deliver on energy efficiency.

The challenge of an absolute energy target such as that set under the EED is that changes in energy consumption are determined by multiple factors, not just energy efficiency. A more meaningful measure would be energy consumption per unit floorspace (e.g. kWh/m^2/yr) or unit of economic output (kWh/£GDP/yr). Of these two, we consider that the rate per unit floorspace is most directly related to the policy purpose under consideration, which is to improve the energy efficiency of buildings.

5.4.2 Setting targets

The purpose of a national target would be to help direct attention and funding towards policies and programmes which work towards achieving the target. We recommend that further analysis is carried out to determine the historic values and most recent baseline of gross energy building efficiency in NI. This will enable a future target value to be set with a clear understanding of its relation to the country's current position.

At a policy or programme level, we have found evidence that the setting of clear targets for key actors can assist in uptake of energy efficiency improvements in the housing stock. Targets and obligations should be simple, easy-to-interpret, and with clear eligibility criteria without being overly prescriptive (Rosenow, 2012c). For example, the Community Energy Saving Programme in the UK (Section A4.1.5) involved targets on energy suppliers which, although not wholly effective in meeting targets due to other challenges, is an example of where this has been used. The Energy Efficiency Standard for Social Housing in Scotland (Section A4.3.4) places a target on social housing landlords which has been considered to be effective, as is the Minimum Standards for New and Refurbished Buildings in Germany (Section A4.5.4).

A related approach is to treat the energy efficiency of the building stock as a national infrastructure priority, as the Scottish Government announced in 2015. Similarly, the CCC recommends that energy efficiency retrofit of the 29 million existing homes across the UK should now be a national infrastructure priority (CCC, 2019a).

5.4.3 Monitoring and measurement

Measuring gross building energy efficiency would require data on total energy consumption exclusive of non-building energy use. Energy consumption data at NI level is readily available, but further investigation should be undertaken to confirm the availability and accuracy of data on the total built floorspace in NI.

At the property level, there is a call to reform monitoring metrics and certification to reflect real-world performance, rather than modelled data (e.g. SAP). Accurate performance testing and reporting must be made widespread, committing developers to the standards they advertise (CCC, 2019b). This approach is being implemented in London under the 'be seen'

planning policies of the draft new London Plan (Greater London Authority, 2018). Under Policy SI2, the draft plan proposes that new building development should not only 'be lean' (using less energy), 'be clean' (exploiting local and clean energy resources), 'be green' (exploiting renewable energy), but also 'be seen' by monitoring, verifying and reporting on energy performance. Major developments are required to report annually to the Mayor for at least five years via an online portal to enable the Greater London Authority to identify good practice and report on the operational performance of new development in London.

The availability of granular and timely energy data was the subject of a recent report by the Energy Data Task Force (Energy Data Task Force, 2019). This report makes several recommendations about regulations and practice on energy data capture and publication; BEIS and Ofgem are "considering these closely" (BEIS, 2019g). It is recommended that DfE liaises with BEIS and Ofgem to confirm how they plan to take forward the Energy Data Task Force's recommendations.

5.5 A one-stop shop and district councils

A one-stop shop approach

Currently in NI, energy efficiency advice is provided through a range of sources and programmes. For example:

- The Northern Ireland Energy Advice Line provides energy advice to householders. It is funded by the Department for Communities and delivered by NIHE. Prior to that, Bryson Energy delivered the energy advice service on behalf of NIHE.
- The Heatsmart Programme provides heating & energy efficiency advice to NIHE tenants.
- The Belfast Warm and Well Project offers advice and practical support.
- The Warmer Ways to Better Health programme is run in conjunction with Antrim and Newtownabbey, Mid and East Antrim, Causeway Coast and Glens, and Mid Ulster councils to support households in fuel poverty through energy efficiency advice and fuel purchasing schemes.

Also, as noted earlier, a district council may promote energy efficiency in residential accommodation in its district by providing financial assistance or advice, and it may produce action plans to improve energy efficiency in residential accommodation in its district.

For most policy levers, a one-stop shop (OSS) approach to provision of associated government services would improve the customer journey and ease of use for the general public and professional customers alike. An effective OSS would be one that engages with building owners, district councils, and installers in order to assimilate customer journeys for individual domestic programmes, or at an organisational level for non-domestic energy efficiency. An OSS service provider covers the whole or large part of the customer chain from information provision, technical assistance, and provision of financial support, to the monitoring of energy savings.

The OSS acts as an intermediary point of contact between a fragmented supply side for energy efficiency services (e.g. designers, suppliers, installers, financiers) into one offer to the building owners (Bertoldi, et al., 2020). Therefore, the building owner need only consult with one individual with the experience of managing the renovation process, rather than having to face every entry point in the renovation value chain. The single contact point is also valuable for the suppliers, who often find it difficult to manage the transactions towards

their potential clients due to the varied requirements, requiring resources for awareness raising and scoping of interventions.

The OSS concept seeks to overcome a number of market failures and behavioural barriers to building renovations, presented in the table below.

Table 21: OSS support for overcoming barriers to building renovation (Interreg Europe, 2019)

Barrier	OSS solution
Lack of information	Provide information, and run campaigns to increase awareness of the benefits of energy efficiency. Provide detailed information to building owners on potential interventions and their expected impact.
Lack of deep renovation capacity	Partner with technical and educational institutions to provide training to contractors.
Concerns over quality of implementation	Develop quality control criteria and certify contractors. Guarantee technical and financial performance of the project. Oversee full project management process and monitor performance of each involved actor. Bring together a number of actors to enable cross-disciplinary cooperation
Reluctance to invest own resources / budgetary constraints	Identify the most financially sound investment and demonstrate savings. Assist in loan or grant acquisition from banks/public authorities. Directly provide funding via ESCO (Energy Service Company) set-up or own fund.
Unattractive financial returns / uncertain repayments	Develop a financially sound investment plan. Aggregate projects to secure higher/more stable returns.
Fragmented supply side	Build long-term links between contractors/suppliers: encourage new co-operation possibilities. Reduce complexity; provide multiple combinations of services and materials through a single contact point.
Fragmented demand side	Build demand through information campaigns and promotion. Pool projects and demonstrate opportunities to construction industry.
Lack of political commitment	Work with local businesses to develop a functioning market; focus on building local political commitment and are aware of local issues. Target other community issues, e.g., energy poverty, rural communities, linking energy efficiency with other regional priorities.
Procurement challenges	Avoid using public budgets; new organisation formed. Help with administration and paperwork.

The effectiveness of OSSs is demonstrated through published research. For example, Boza-Kiss & Bertoldi (2018) found OSSs to be effective because:

- They are local to the consumer;
- They accelerate building refurbishments by informing, motivating, as well as by assisting building owners to follow through energy efficiency investments, by standing beside them from the start to the end;
- They can facilitate interested, but not yet committed energy users / asset owners to actually implement an energy saving or other type of sustainable project;

- They can ease access to financing and occasionally offer better rates; and
- They can also improve the average renovation depth in terms of energy performance, because an OSS walks through the full renovation route.

Stakeholders reflected on SEAI in RoI, commenting that all energy efficiency schemes should be filtered through this via a dedicated helpline that would field calls and deal with queries throughout the referral process. The aim of this approach to ensure householders are navigated through the differing available schemes to achieve the best outcome.

It has been shown that householder engagement is improved where information and initial contact come from a trusted source, which is perceived as likely to act in their best interests and to provide impartial advice (SEAI, 2017a). Stakeholder engagement confirmed the view that an OSS could be beneficial to provide impartial information on energy efficiency, and it was thought to be important that this advice comes from an organisation that it independent from the government. This independent organisation should also act as guarantor or auditor of proposals.

An OSS could be particularly effective in providing continuity, for example, to potentially mitigate against the periodic nature of schemes, for example, the NISEP bidding rounds which may not be advantageous for multi-year rollouts of energy efficiency improvements.

In addition to the role of SEAI in RoI, an example of an OSS approach is illustrated in Scotland, where Energy Saving Trust manages five advice centres that together cover all of Scotland. Advisors offer free, impartial advice on energy saving, keeping warm at home, renewable energy, greener travel, and cutting water waste. Energy Saving Trust also delivers the policy support programmes for Scottish Government, so the operational teams for these programmes are well linked to the advice centre teams.

The role of district councils

Local organisations are well placed to understand specific local requirements and opportunities, tackle local delivery challenges and integrate decarbonisation, energy efficiency and fuel poverty programmes on the ground (Fudge, et al., 2012). They may also be better able to generate public support for projects and overcome consumer barriers (ibid.).

Whilst stakeholder engagement revealed a view that it would be advantageous for NI to have an OSS rather than 11 distributed agencies in the form of district councils, there were also views that district councils could play a role in an OSS approach. It is thought that local bodies have better potential to be trusted, and this is key since at every stage in the retrofit process, property owners must feel confident in the advice, design, funding, and physical works.

Where a community-led approach is being considered, district councils could play a number of roles, including recruitment of participants, coordination with statutory services (e.g. utilities and highways authority) and facilitating contractor vetting and procurement. If a community-led approach is to be delivered at scale, district councils could play an important programme management role to support and coordinate across multiple community-led schemes. Potentially, district councils could also act as "supplier of last resort" with step-in rights in the event that a scheme could not be completed by the community organisation.

However, as described in section 2.6.2, district councils currently have limited responsibilities for energy efficiency and building stock. Therefore, district councils may lack the relevant capabilities and be reluctant to take responsibility for a new area of policy before securing the necessary resources to be successful. This point was illustrated by NI

Local Government Association's feedback that although they recognise the requirement for action on energy efficiency, they are uncertain about responsibility being placed on district councils at present.

As described in section 2.6, district councils play a role in terms of planning policy, and possibly in terms of local financial incentives.

5.6 Skills requirements

Building retrofits require a blend of general and specific construction skills. Building retrofits, especially to higher levels, will require construction workers/installers to develop new technical skills both to fit new upgrade measures and to address significant performance gaps. Closing these performance gaps requires greater attention to be paid to the detail and quality of installation, and this in turn requires coordination between the different trades (e.g. builders, gas engineers, plumbers and electrical engineers).

A number of retrofit programmes in the UK have needed to pull back from generating demand for home upgrades due to a lack of a local supply chain. As much as a customer needs to be led through a smooth transition from awareness, consideration, acquisition, delivery and follow-up (the one-stop-shop) so the supply chain needs its own journey. Contractors need to be made aware of the opportunities in the market, engaged, supported in upskilling and monitored for quality and service. For example, RetrofitWorks, based in London, is a cooperative owned by community-based organisations and local supply chains to design and host energy efficiency schemes. They recently recruited a person to specifically to work on the engagement of the supply chain. Also, until recently, all marketing channels for their Cosy Homes scheme were directed towards customers; however, work is underway to split the website, creating a marketing channel specifically for their supply chain.

From the perspective of ensuring quality retrofits, good practice guidance is available from Publicly Available Specification (PAS) 2035 which came into effect on 30 June 2019. It is a specification for the energy retrofit of domestic buildings and best practice guidance about domestic retrofit projects (BSI, 2020). It is intended to support the TrustMark Government-endorsed quality scheme for domestic retrofit and to be applied to any domestic retrofit work carried out in the UK (ibid.). Projects compliant with PAS 2035 need a designated Retrofit Coordinator to provide coordination from project inception to handover, and through monitoring and evaluation (ibid.).

More broadly, research by Owen et al. (2014) has highlighted six skills sets (see Table 22) that need to be developed in order to deliver building retrofits, of which technical skills is only one. Greater emphasis needs to be placed on the other 'soft skills', especially amongst the SMEs that dominate the domestic property upgrade sector. The role of further education is crucial here: technically focused programmes – whether in technical colleges or in-work training – need to develop to support initial vocational training with a curriculum that reflects the broader requirements of building retrofits, as well as to unlock the potential of continuing professional development. A local accreditation scheme regularly renewed and linked to locally applicable standards of building retrofit performance could be a useful vehicle here. A local/regional pilot scheme could play a crucial role here, especially if it could be nationally recognised in order to enable more rapid evaluation and learning to feed into national policy discussions.

Table 22: Required supply chain skills (Owen, et al., 2014)

Proposed sub-category	Description	Effect and mode of impact
Installer capacity - technical	Knowledge of the technology function and requirements; skills in specifying, designing and installing effective domestic energy technology.	Sets the technical effectiveness of proposed solutions i.e. the maximum potential benefits from energy technology adoption.
Installer capacity - adaptive	How well does the installer gather information about the situation in which technology will be deployed and tailor design and advice to a specific situation?	Enhances the compatibility of the energy technology for the adopter.
Installer personal impact	The social skills and communication abilities that enable the installer to work effectively with adopters. Demonstrating respect for people's homes.	Influencing the potential adopter's attitudes towards technology and, by association, the pro-environmental behaviours and outcomes that the technology can enable.
Installer motivation	Why does the installer advise, design and install? What outcomes to they hope to see from their work?	Sets priorities in design and commissioning. Sets parameters for self-limiting impact.
Installation perception	Was installation a positive or negative event from the householder's viewpoint? This includes physical impacts and disruption, information sharing and interactions with the adviser or installer.	Affects householder's perception of the technology and, by association, their perception of the impact of the technology.
Installation aftercare	What is the result of the commissioning process? Is there any knowledge transfer or capacity building for the householder? What maintenance and check-ups are required?	Does the adopter understand how they can affect the technology's function? Ensures impact of the technology by checking it is functioning as intended and repairing or upgrading as required.

There is also a wider ecosystem where new skills and a more joined-up approach that emphasises both the level of ambition/depth of building retrofits and the quality of installation is needed. This ecosystem includes policy makers, planners, developers, architects, surveyors, original equipment manufacturers and material/product suppliers, lenders, builders' merchants and building controllers/quality assurers.

Therefore, it is recommended that a local/regional pilot scheme is set up to increase understanding of the supply chain skills and the need to establish a local accreditation scheme. Developing parallel business models for the private and social sectors can provide a much-needed stimulus for the investment required in the supply chain.

6 Conclusions and recommendations

6.1 Overview

Through the evidence in this report, we have demonstrated that there is a need for a **dramatic shift in the scale and pace of energy efficiency roll-out** in order to meet the target of achieving net zero carbon by 2050. We have developed three key areas of recommendation:

- There is a need for **a blend of policy levers;** no single policy can deliver this change alone (as set out in 6.2);
- The scale of the change required will **need significant investment,** and there are choices in the main funding routes (as set out in 6.3); and
- **Policy design and implementation is critical to success,** and there are a number of factors that need further consideration (see 6.4).

6.2 Lever recommendations

The modelling presented in the previous section illustrates that a significant increase in energy efficiency is required for NI to contribute in line with UK carbon reduction targets to reach net zero by 2050. For the High scenario, the peak number of building upgrades per year is estimated to be approximately 53,000, which is approximately three times annual figures associated with the combined total of the current NISEP, Affordable Warmth, Boiler Replacement, and RECG schemes combined. The effectiveness of the measures themselves also needs to be greater: the peak of resulting annual energy savings in the High scenario is estimated to be 14 times the historic annual figures for the total of the aforementioned programmes[19].

Our research has identified that single policy levers will under-deliver; a coordinated portfolio of levers is required that provide long-term support across building tenures, illustrated by the table below that formed the basis of the modelling.

Table 23: Applicable tenures for the lever types

Lever type	Fuel Poor	Social housing	Able to pay	SMEs	Large Enterprise	Public
Funding - grants	✓			✓		
Funding - loans		✓	✓		✓	✓
Programme delivery	✓	✓	✓	✓	✓	✓
Other financial incentives		✓	✓		✓	✓
Standards	✓	✓	✓	✓	✓	✓
Building regulations		✓	✓	✓	✓	✓
Planning policy				✓		
Public reporting	✓	✓		✓	✓	✓
Technical support	✓	✓	✓	✓	✓	✓

[19] On a domestic tenure basis, the peak High scenario annual energy savings are estimated to be 11 times the total of the current schemes. On a non-domestic tenure basis, the peak High scenario annual energy savings are estimated to be 40 times the total of the current schemes.

We estimate that the modelled High scenario most closely illustrates the level of ambition required, and includes the following levers:

- Standards, including minimum energy efficiency standards (MEES) for all existing buildings. MEES are modelled to provide a significant proportion of the projected energy savings. This type of lever has already been implemented in England and Wales, and is proposed in Scotland, with increasingly stringent targets to the year 2040. Standards "on paper" would need to be supported by government resources for their promotion, advice and enforcement. Targeted technical and financial support through grants and loans could enhance effectiveness, especially where cost of measures exceeds the exemption threshold.
- Other financial incentives such as such as rates or stamp duty incentives for Able to Pay domestic tenure groups, large enterprises, and public sector.
- Programme delivery through local or national government action to appoint supply chain partners for the rollout of retrofit in all existing building tenures.
- Technical support through advice for target groups encourage the uptake of interventions for all existing building tenures.
- Loans for building energy efficiency improvements for Able to Pay domestic tenure groups, public sector, and large enterprises.
- Grants for building energy efficiency improvements for all Fuel Poor domestic tenure groups and SMEs.

Expenditure estimates

The levers above have been modelled for corresponding relevant intervention measures. For the High scenario, the interventions are estimated to require a total capital expenditure across the economy, for domestic and non-domestic buildings combined, of £6.4 billion over 27 years, in today's prices. Therefore, this equates to approximately £236 million per year if averaged equally over each deployment year.

For the 2016 EnergyWise consultation, DfE estimated that 95% of the costs would be used directly for grants to assist with the cost of energy efficiency measures and the remaining 5% would contribute to indirect costs such as administration, promotion, quality assurance, running the phone line etc. (DfE, 2016). Taking this 5% figure combined with the total estimated capital costs results in estimated public sector administration costs of approximately £12 million per year.

6.3 Choices for funding mechanisms

There are two main routes for funding energy efficiency roll-out grants that will be required for some key segments:

- Through general taxation; or
- Through an EEO on energy companies.

Through the evidence collected for this report, there is no clear evidence that either route is inherently *better* than another. It is likely to be appropriate for whichever route taken from a funding perspective to be closely linked to the delivery body for programme roll-out (i.e. public sector or energy company). Both public sector or energy company are likely to have some of the skills required, but not all of them, and not at the scale required to deliver the pace of change needed.

With regards to the EEO, the advantage is that it offers a relatively simple outsourced mechanism for funding and delivery of energy efficiency investments. The money is collected through energy bills and recycled in the form of energy savings investments for (some of) those same customers. A key disadvantage is that it can risk being a regressive measure which places a relatively greater burden on low income customers. Furthermore, the low penetration of natural gas in NI makes its application more complicated to avoid the distortion of the market by putting a premium on the price of lower carbon gas relative to higher carbon oil heating.

Moreover, it is widely recognised that benefits of energy efficiency investments far exceed the direct financial savings from reduced fuel use. The EEO would need an additional funding or subsidy mechanism to capture the full benefits, or else the measures would be limited to "low hanging fruit" and would fall short of the pathway consistent with a net zero commitment.

We recommend market research with consumers and building users to establish levels of trust in both types of organisation to determine the preferred funding mechanism.

6.4 Design and implementation factors

Based on the evidence in this report, we recommend that a national 'one-stop shop' built on best practice customer journeys to simplify the process for building owners and occupiers and build trust in the advice and works necessary. A 'one-stop shop' designed to provide the following elements is likely to be the most successful. Each component will need careful design and engagement to deliver effectively. A proposed approach is presented in the table below.

Table 24: A proposed approach to energy efficiency in buildings

Element	Outcomes
1. Space for collaboration	A broad network of national, regional, and community stakeholders that collaborate to address the multiple barriers and opportunities by sharing objectives, networks and resources.
2. A successful communication and engagement campaign	Develop a community-based social marketing approach; e.g. using social media influencers, and trusted local partners to deliver key messages.
3. A strategic plan and programme for delivery	Establish a development roadmap based on the outputs of working groups with a 'do now, do soon, do later' structure and 'no regrets' approach taking into consideration the readiness assessment and the inter-relationships between the different elements.
4. Monitoring and reporting targets	A direct link between upgrade targets optimised across the entire building stock and net zero carbon ambitions to drive commitment and collaboration across all stakeholders.

Element	Outcomes
5. An approach to maximise social impact	An approach that measures and maximises the wider social impact benefits of building retrofits in order to galvanise wider support and potential blended finance approaches. Beyond the climate change and energy targets, there are co-benefits to energy efficiency including: • warmer and drier homes in winter lead to physical and mental health benefits which will reduce demand on the NHS and social care; • improved learning, because of reduced school absenteeism from illness and because children learn better in warm homes; • reduced impacts on vulnerable households from increases in energy costs; the creation of a substantial market for local firms supplying energy efficiency products and services; • higher employment and higher incomes; • lower rent arrears for social and private landlords; and • less investment will be needed to generate, store and transmit decarbonised energy. These co-benefits were illustrated by a study by Arup for the Strategic Investment Board (SIB, 2014) which showed that improving the energy efficiency of 60,000 homes in fuel poverty in NI would generate a social return on investment (SROI) of between 4 and 15, depending on assumptions. Another example of co-benefits comes from Scotland. The rollout of the Energy Efficient Scotland Programme is estimated to create a substantial Scottish market and supply chain for energy efficiency services and technologies, with every £100 million spent on energy efficiency improvements in 2018 estimated to support approximately 1,200 full-time equivalent jobs across the Scottish economy (Scottish Government, 2018b).
6. Quality assurance	An approved set of standards and effective delivery and monitoring mechanisms to provide confidence in both the recommendation of interventions and the quality of the work subsequently carried out that is robust enough to support funding mechanisms and simple enough to enable wide-spread adoption in the supply chain and understanding in the community.
7. Provision of technical models to support a targeted roll-out	A solid foundation of technical understanding of the archetype-specific challenges, costs and benefits associated with the 'whole house' plans necessary for net zero ambitions including the individual interventions and the most appropriate logical order for phased, 'no regrets' approaches.
8. Access to funding	A suite of funding models that mean building owners are willing and able to fund and/or participate in building retrofits. This may include an effective blend of grants, personal investments, loans, and 'pay as you save' models.
9. Support for the supply chain	A skilled, coordinated and quality assured supply chain supporting where possible the local economy and which is of the scale required to match credible, significant and stable future demand.
10. Delivering local pilots	A particular criticism of the Green Deal by the National Audit Office (2016) was that its ideas were not tested. Therefore, pilots should be developed for the technical, quality assurance, business and finance models with a focus on the relationship between them and an emphasis on stimulating demand in a way that will mobilise the supply chain.

Appendices

Appendix A : Literature Review

Appendix B : Stakeholder descriptions

Appendix C : Planned or projected growth areas

Appendix D : Building characteristics by tenure and location

Appendix E : GIS outputs

Appendix F : Low and Localised scenario results

Appendix G : Intervention costs

Appendix A: Literature Review

A1 Structure of this report

This report provides a summary of the literature review. The structure of this report is set out as follows:

- **Section 2. Approach**: this section provides an overview of our approach to the literature review.
- **Section 3. Energy efficiency in Northern Ireland (NI)**: this section sets out the NI context with regards to energy efficiency, including the characteristics which influence the effectiveness of policy levers in NI, and an overview of the policy levers we have focused on.
- **Section 4. Energy efficiency in other geographies**: this section sets out the context of other geographical regions with regards to energy efficiency and associated policy levers, focussing upon the UK, RoI, Scotland, Wales, the Netherlands and Germany. It also provides a comparison of policy environments with that of NI including how responsibilities are organised and the level of funding assigned to energy efficiency.
- **Section 5. Behavioural change:** this section provides an overview of behaviour theory and influence over policy.

A2 Approach to the literature review

The literature review has involved a systematic review of existing and potential future energy efficiency policy through academic literature and reports and data from governments and public bodies. The review has focused on policy in NI and other key geographies, as agreed with the DfE.

An initial review of key energy efficiency policy levers in each geography was undertaken, using government sources to identify policy levers which have been implemented to tackle energy efficiency over recent years. This included a high-level review of publications developed under the European Union-funded Odyssee-Mure project which undertakes comprehensive monitoring of efficiency trends and policy evaluation in EU countries.

Following this, we undertook a keyword search of academic literature and other online sources to identify relevant literature to support our understanding of policy effectiveness in each region. We identified key academic experts in energy efficiency policy and undertook a review of their publication list and bibliographies to identify further literature.

Stakeholder engagement has enabled us to understand views on the effectiveness of past and current energy efficiency policies and programmes, perceptions of market failures within the energy efficiency industry, and to fill gaps in our understanding. The findings of the literature review will be used alongside the stakeholder engagement results to assist in the evaluation and prioritisation of policy options, which will be documented in the final report.

A3 Energy efficiency in Northern Ireland

A3.1 Context

A3.1.1 Background to the Northern Ireland energy market

This section describes contextual features relevant to energy efficiency policy in NI.

- The NI population is projected to grow from 1.862 million in 2016 to 1.982 million by 2035, an increase of 120,000 people (DfE, 2018). Projections for the number of households in NI (2012 based) indicate growth from 709,000 households in 2012 to 807,000 in 2035 (Ibid.).
- The arrangement of the NI electricity system is similar to that found in other markets such as Great Britain. It consists of the following distinct businesses: generation, transmission, distribution, and supply. Generation is provided by private sector companies who own and operate power stations and generators such as wind farms. NI also has interconnectors between the Scottish and RoI grids through which electricity can be imported and exported. Northern Ireland Networks Ltd (part of the ESB Group) owns the transmission and distribution network and operates the distribution network which transports electricity to over 887,000 customers.
- Like neighbouring regions, NI has a privatised electricity supply market where consumers can choose from a number of private sector electricity suppliers. Renewable electricity generation in NI has increased considerably over the past 10 years, from approximately 10% in 2010 to 47% of total electricity consumption for the 12-month period between April 2019 to March 2020 (DfE, 2020b).
- Over the period 2014-2016, Low Carbon and Renewable Energy activity provided around 5,500 direct full-time equivalent (FTE) employment, with Energy Efficient Products accounted for 50% of these. For comparison, there is a total of 216,000 direct FTE employees in NI (DfE, 2018).

Distinguishing features of the NI energy supply and use include:

- Whilst the transmission network in NI is operated by the System Operator for Northern Ireland (SONI), all wholesale electricity across the island of Ireland is bought and sold through a single pool, which has increased competition, efficiency and security of supply (Uregni, 2016). The operation of this Single Electricity Market (SEM) requires the physical connection of the NI grid to that in RoI. The operation of this market is facilitated by the Single Electricity Market Operator (SEMO). SEMO is a contractual joint venture between the two system operators - SONI in NI and EirGrid Plc, their counterparts in the RoI.
- Within the domestic sector, approximately 45% of electricity customers, and 65% of gas customers, use prepayment meters (Uregni, 2020). This is higher than in Great Britain where 15% of domestic meters were prepayment in 2019 (BEIS, 2020b). Research shows that prepayment meter customers tend to have high vulnerability representation (Ofgem, 2019).
- There is a high use of oil for heating (68% of homes, with 82% in rural areas) compared to only 25% using mains gas for the year 2016 (NIHE, 2018). For comparison, 86% of households are connected to the mains gas network in Great Britain (BEIS, 2019). In NI, there are four transmission pipelines, and three distribution licensed areas within Northern

Ireland. 60% of Northern Ireland households are expected to have access to natural gas by 2022 (Uregni, 2018).

- NI had the highest weekly household expenditure on energy of any UK region; it was 18% higher in the period 2014-2017 than the UK average. However, the gap has narrowed considerably in recent years (from 36% in the period 2012-2014). Weekly expenditure on gas in NI was less than a third of the UK average expenditure but households in NI spent about 9 times as much per week on other fuels (e.g. home heating oil) compared to the UK as a whole in the period 2014-2017 (DfE, 2018).
- In Quarter 4 2017, NI non-domestic electricity prices were around 9% lower than the UK in the very small category and 1% lower in the small category; they were 1% higher in the small/medium category, but 12% lower in the medium category and around 24% lower than the UK in the large/very large category (DfE, 2018).
- Fuel poverty in NI was reported as 22% of households for the year 2016 (NIHE, 2018)[20], compared to 10% in England in 2018 (BEIS, 2020a)[21]. Fuel poverty in NI varies by tenure with the highest proportion in fuel poverty in 2016 being the private rented sector (26%), followed by the owner-occupied sector (23%). The social housing stock had a fuel poverty rate of 10%, reflecting in part the much newer stock managed by housing associations.
- A study for the Strategic Investment Board (SIB, 2014) included a consultation where it was highlighted that that owner-occupied homes were some of the poorest insulated and energy inefficient across NI. This was in part due to initiatives addressing issues in the social housing sector and/or targeting the most "at risk" from fuel poverty, and as such, missing out owner-occupied homes. Some considered that many might be regarded as cash poor, but asset rich. This, it was stated, led to a situation where households could not afford to heat their homes. This was considered as being particularly pertinent for the elderly, indeed, the House Condition Survey (NIHE, 2018) shows that of those households with residents aged 75 and over, 38% were in fuel poverty, and the corresponding figure was 25% for the 60 to 74 age group, 17% for the 40 to 59 age group, 13% for the 25 to 39 age group, and 25% for those aged between 17 and 24).

A3.1.2 Building characteristics

The effectiveness of energy efficiency policy levers will depend upon the characteristics of the buildings within which they operate. Table 25 provides an overview of the characteristics which should be taken into consideration when developing policy in NI and will influence the effectiveness of policy levers.

According to the 2016 House Condition Survey (published in 2018), 49% of the dwellings are between the Energy Efficiency Rating (EER) bands A and C[22]. Higher EERs are more

[20] It is noted by NIHE that fuel prices in 2016 were relatively low and this was a major contributor to the relatively low fuel poverty rate compared to the figure of 42% reported in the 2011 survey. The effect of heating oil price is also reflected in NIHE's lower estimates of fuel poverty for subsequent years when heating oil prices were lower (NIHE, Greene and Brown, 2019).
[21] Fuel poverty in England is measured using the Low Income High Cost (LIHC) indicator, which considers a household to be fuel poor if: they have required fuel costs that are above the national median level; and were they to spend that amount, they would be left with a residual income below the poverty line.
[22] 33% (165,965 out of a total of 499,570) EPC lodgements are between bands A and C according to DoF (2020) data. Note that the DoF data may contain multiple EPC lodgements for the same building, however, this cannot be ascertained from the data supplied to Arup.

likely for newer dwellings, for those in urban areas compared to rural, and for those households with children compared to households with older occupants.

Almost all dwellings in NI have central heating[23] (99% in 2016). 65% of dwellings have a full cavity wall insulation, 15% have partial insulation and 20% have no wall insulation. Prevalence of no wall insulation is greatest in private rented homes (37,310 homes, 5% of total stock). Loft insulation thickness of more than 100mm has been applied in over 88% of dwellings, and a thickness of more than 150mm across 54% of dwellings. However, Part F (Department of Finance and Personnel, 2012) states a typical cost-effective insulation thickness of 270mm and therefore the suitability of the existing building insulation is not apparent from the NIHE House Condition Survey. Full double glazing is found in 87% of dwellings, while 9% have partial glazing.

The NIHE commissioned a study (Consultancy Investigation and Training (CIT), 2019) into the condition of cavity wall insulation and its impact in terms of thermal efficiency and technical defects across a representative sample of social housing properties, and a sample of private home properties. A series of recommendations emerged from the study, including the need for monitoring to check quality of works, introduction of competencies and standards that suppliers must adhere to, and advice for residents.

Data relating to non-domestic building characteristics is not readily available, although the Energy Management Strategy 2019 provides an overview of energy consumption across NI Government buildings which indicates it is slightly higher than the UK average (although there are variations in benchmarking) and has remained fairly flat over the previous six years (SIB, 2019).

Table 25: Building characteristics in NI

Responsibilities and powers relevant to energy efficiency	High proportion of public sector building ownership, and central government ownership of schools.
Fuel use in homes	High use of oil (68% of homes) compared to only 25% using mains gas (2016)
Tenure split	Tenure split is: Owner Occupied 63.4%; Private Rented and Others 17.4%; Social Housing 15.5%; Vacant 3.7%. (NIHE, 2019b)
Geographic setting	Urban 64%; Rural 36%. (Ibid.)
Housing stock	Approximately 790,000 dwellings in NI in 2016 (Ibid.)

A3.1.3 Market failures and public sector intervention

The economic rationale for public sector intervention (such as policy) is that the market sometimes fails to produce optimal outcomes for society as a whole. The Stern Review on the Economics of Climate Change set out that climate change is the greatest and widest-ranging market failure ever seen (Stern, 2007). It described the need for policy to promote sound market signals, overcome market failures and have equity and risk mitigation at its core.

[23] Heating system with a distribution system, or a heating system with some means of controlling temperature and timing, for at least two rooms.

Market failures can range from long-established neoclassical market failures (e.g. externalities) to systems failures including social and cultural barriers. In the table below, we summarise the key market and systems failures identified through our literature review.

Table 26: Key market and systems failures affecting energy efficiency. Sources: (National Energy Foundation and Energy Efficiency Partnership for Buildings, 2014), (SEAI, 2017)

	Barrier	**Key Features**
Market failures	Inadequate information	High levels of specialised technical and/or market knowledge mean that not all the economic actors involved have the basis for making informed decisions.
	Environmental externalities	The cost of carbon (and future costs of a changing climate) is not captured in economic decision-making.
	Economics	Building retrofit measures are characterised by high capital costs and return on investment in terms of added property value / rental income is low. Low-cost funding is difficult to access.
	Broader innovation and adoption externalities	The size of scientific/technological problems is too great for individual private actors to tackle and may be accompanied by uncertainty, making it hard for the private sector to invest. For NI, there is prevalence of heating oil use which may be related to the broader externality of the limited coverage of the gas network.
	'Landlord/tenant split incentives'	This significantly constrains the uptake of efficiency measures in rented property. This failure results from the common situation whereby a landlord is responsible for meeting the cost of the improvement work, but only receives a benefit where the work increases the rental or re-sale value of the property. The tenant, who is typically responsible for paying the energy bills and would thus see the benefit of the work, is unlikely to be willing to invest in a property they do not own, or may not be permitted to undertake the improvement work. 17% of households in NI live in rented accommodation. The *Northern Ireland Private Tenancies Order 2006* aims to address the barrier of split incentives between landlords and tenants. The Order states that a tenant must obtain the landlord's consent to carry out alterations to the property, but this consent cannot be unreasonably withheld (DECC, 2014).

System failures	Capabilities	Firms lack required skills, resources, and ability to learn to provide the goods and services required to deliver energy efficiency. SMEs face various barriers that deter them from adopting energy efficiency measures; they often lack the time and resources to explore energy efficiency options (IEA, 2017).
	Behaviours	Tendency to pick lowest cost measures and 'low hanging fruit' rather than a focus on long-term cost savings and more difficult installations. Resistance to disruption from major works. Building improvements are typically undertaken at purchase or sale of house. Landlords see disruption as a cost due to loss of rental income.
	Collaboration	Lack of a joined-up and consistent approach by actors delivering energy efficiency creates a complicated process and confusion by building owners.
	Lack of awareness	Lack of awareness of energy efficiency measures and appreciation of benefits of improved energy efficiency. Partly as a result of the lack of trusted information, the long-term benefits of improved energy efficiency are often regarded as less certain. Consequently, energy efficiency is undervalued relative to other investment options and not prioritised as it might otherwise be. SMEs lack information about where and how energy is used in their businesses (IEA, 2017). The Consumer Council (2018) commissioned a research study that included 12 focus groups with a range of householders and found that most people were unfamiliar with any energy efficiency provisions available in NI, including NISEP and its individually named schemes. Where there was awareness, this tended to be vague.

A3.1.4 Energy efficiency responsibilities

In the UK, the devolved nations each have responsibility for the promotion of energy efficiency policy and programmes. NI is unique however in that it holds responsibility for legislating policies relating to energy efficiency, unlike Scotland and Wales for which this responsibility is retained by the UK Government (the Department for Business, Energy and Industrial Strategy).

Whilst energy policy is devolved to the NI Assembly, it is framed by international and European policy. The Paris Agreement sets a global commitment for the reduction of carbon emissions and, as a result, the EU issued the Clean Energy Package for Member States to plan, implement, monitor and evaluate policies on a range of areas, including energy efficiency. Whilst there is uncertainty about the future relationship between UK and EU energy policy, the UK Climate Change Act 2008 is the basis for the UK's approach to tackling and responding to climate change. It now requires that emissions of CO_2 and other greenhouse gases to be reduced by 100% by 2050 from 1990 levels, commonly referred to as the 'net zero 2050' target.

The Department for Enterprise, Trade and Investment (DETI), now the DfE, published the Strategic Energy Framework (SEF) for NI 2010, which sets the direction of travel for energy policy in NI until 2020. The vision of the Framework is a competitive, sustainable, reliable energy market. This is underpinned by the goals of: competitiveness; security of supply; developing energy infrastructure; sustainability. Work is currently underway to develop a new Energy Strategy for NI.

NI's DfE has overall responsibility for energy and the economy, however there are other government departments which have responsibilities relating to the management and delivery of energy efficiency. The table below presents relevant organisations (in alphabetical order), along with their responsibilities and areas of work relevant to energy efficiency.

Table 27: Organisations with energy efficiency responsibilities for NI

Organisation	Responsibilities or areas of work
BEIS (UK Department for Business, Energy and Industrial Strategy)	UK Government department with responsibility for business, energy and industrial strategy. This includes science, innovation, energy and climate change policy. In the context of NI, energy policy is devolved and therefore policy set by BEIS may set a framework within which funding can be requested from HM Treasury, and in which NI policy can be made.
Bryson Energy	Bryson Energy has operated a range of fuel poverty and health related programmes such as Warm Homes, grant administration, oil buying clubs, budgeting advice, handyperson, benefit checks and several retrofit programmes.
Committee for Climate Change (CCC)	An independent, statutory body whose purpose is to advise the UK Government and devolved administrations on emissions targets
Consumer Council NI	The Consumer Council is a non-departmental public body (NDPB) established through the General Consumer Council (Northern Ireland) Order 1984. Its principal statutory duty is to promote and safeguard the interests of consumers in NI. The Consumer Council has specific statutory duties in relation to energy, postal services, transport, and water and sewerage. These include considering consumer complaints and enquiries, carrying out research and educating and informing consumers.
Department for Communities (DfC)	Statutory responsibility for promoting efficient use of energy in the domestic sector (SIBNI, 2019). DfC is responsible for funding, monitoring, regulation and issue of guidance and policy directives to registered housing associations. It has a statutory duty to consult with representatives of housing associations. DfC liaises regularly with NIFHA on policy and legislation issues.
Department for Infrastructure (DfI)	Main responsibilities: regional strategic planning and development; transport strategy and sustainable transport; public roads; public transport; air and seaports; water and sewerage services.
Department for the Economy (DfE)	Lead department responsible for providing the strategic vision for the future of energy in NI, as well as key aspects of the energy legislative framework including the licensing and regulatory framework and a range of consumer protection issues (DfE, 2019).
Department of Agriculture, Environment and Rural Affairs (DAERA)	Lead department for climate change. DAERA is also currently developing a Clean Air Strategy, which includes tackling air pollutant emissions from road transport, industry and home heating.
Department of Finance (DoF)	Responsible for policy and legislation on building regulations (whilst enforcement is a matter for district councils) and energy performance certification of buildings.
Energy Saving Trust NI	Manages the NI Sustainable Energy Programme (NISEP) on behalf of the Utility Regulator. NISEP provides grants to help implement energy-saving measures in domestic and commercial properties, such as grants for energy-efficient boilers, heating, loft insulation and cavity wall insulation.

Organisation	Responsibilities or areas of work
HM Treasury, UK	May provide funding from UK Government. HM Treasury collects revenues due to energy efficiency programmes and taxes such as Climate Change Levy (CCL).
Invest NI	A Non-Departmental Public Body of DfE, with an aim to help new and existing businesses to compete internationally, and attract new investment to NI. Promotes resource efficiency and energy efficiency in the commercial and industrial sector.
National Energy Action NI	Designs and delivers projects to demonstrate new and innovative ways to tackle fuel poverty. Works in partnership with district councils, housing associations, the health sector, the energy industry, and other public and private organisations. Influences strategic development; enhances delivery capabilities and brings affordable warmth to communities, including through the following programmes: Belfast Warm and Well Project; Northern Exposure; Affordable Warmth; and the Smart Meter Project.
Northern Ireland Authority for Utility Regulation (NIAUR) ("Utility Regulator")	Responsible for regulating the electricity, gas, water and sewerage industries in NI, promoting the short- and long-term interests of consumers. Delivers the Norther Ireland Sustainable Energy Programme (NISEP), which is managed by Energy Saving Trust NI. Aims to contribute to the promotion of sustainable development in exercising its regulatory duties. This includes promotion of efficiency in the use of electricity and gas, and protection of the welfare of electricity, gas and water customers, with due regard for the needs of vulnerable customers.
Northern Ireland Environment Agency	The NI Environment Agency is an executive agency within DAERA. One of the Agency's key priorities is to promote environmentally sustainable development and infrastructure. The Agency is the regulator of the Energy Savings Opportunity Scheme (ESOS) for organisations whose registered office is in NI.
Northern Ireland Federation of Housing Associations (NIFHA)	The representative body for NI's 20 registered housing associations.
Northern Ireland Housing Executive (NIHE)	In its role as the Home Energy Conservation Authority (HECA) for NI, it seeks to strategically plan and support improvements in home energy efficiency across the entire housing stock in the region. This includes carrying out and/or supporting research to promote innovation and help track the progress of energy efficiency programmes and projects. Since April 2020, NIHE has also had responsibility for the Energy Advice Line, Oil buying clubs, and schools programme.
Northern Ireland Local Government Association (NILGA)	The council led representative body for district councils in NI.
Northern Ireland Statistics and Research agency (NISRA)	Executive agency within the Department of Finance. Responsible for the collection and publication of statistics related to the economy, population and society of NI.
Strategic Investment Board (SIB) Energy Management Unit	Prepares the Investment Strategy on behalf of the NI Executive (ISNI). Helps the public sector develop and deliver major programmes and projects. Operates the Asset Management Unit (AMU). The Energy Management Strategy and Action Plan to 2030 follows a review of energy management opportunities across public assets in order to reduce demand and costs, generate revenue and provide a road map for delivery of energy and cost savings. SIB is providing the Programme Director and Programme Manager for the initiative. They work closely with the DfE, who are the sponsor. The SIB communications team provides advice and support for the project (Strategic Investment Board (SIB), 2019).

A3.2 Policy levers

The table below presents an overview of past and current policy levers in NI. Where evidence is available, policy levers are covered in further detail in the following sub-sections.

Overlaps can exist in the types of properties or tenures that multiple policy levers may aim to address. For example, both the NISEP and the Affordable Warmth Scheme aim to provide support to vulnerable and low-income consumers. This can make it challenging to identify the benefit achieved by a single policy lever.

Table 28: Energy efficiency policy levers in NI

Policy lever	Applicable dates	Summary	Further detail
NISEP	2010 – 2024	An annual programme of energy efficiency schemes, with origins in the Energy Efficiency Levy which began 1997. The funding is split is 80% to priority (vulnerable) domestic customers and 20% to non-priority domestic and business customers.	A3.2.1
Warm Homes Scheme	2001 – 2015	Grants were provided to vulnerable owner-occupiers and private-rented households for energy efficiency measures.	A3.2.2
Affordable Warmth Scheme	2014 – present	Grants are provided to tenants living in privately-owned domestic properties.	A3.2.3
Energy Efficiency Loan Fund	2003 – 2018	Fell under the Sustainable Development Support Programme (SDSP) led by Invest NI. Provided loans to businesses for investing in energy efficient equipment and/or renewable technologies.	A3.2.4
Resource Efficiency Capital Grant	2015 – present	Falls under the SDSP. Grants up to a maximum of £40,000 per application, for equipment supporting resource efficiency, not strictly energy efficiency. Scheme delivered by Invest NI.	A3.2.5
Building Regulations	Ongoing	Minimum standards to which the erection, extension, or material alteration of buildings must adhere.	A4.1.1
Technical Consultancy and support	Ongoing	Falls under the SDSP. Up to five days of free consultancy support to help businesses manage and implement resource efficiency projects.	-
Industrial symbiosis service	2007 – present	Falls under the SDSP. Support for industrial symbiosis, so not strictly energy efficiency. Supports identification of opportunities for physical exchange of wasted resources between organisations. Delivered by International Synergies NI Ltd on behalf of Invest NI.	-

Boiler Replacement Scheme	2012 - present	NIHE provides grants to owner occupiers with gross household income below £40,000 and an inefficient boiler of at least 15 years old. A grant of up to £1,000 is available to help with replacing an inefficient boiler with a more energy efficient condensing oil or gas boiler; switching from oil to gas; or switching to a wood pellet boiler. In 2017/18 £2 million was invested in the installation of new energy efficient boilers (NIHE, 2018).	-
Heatsmart Programme	Ongoing	Heating and energy efficiency advice to NIHE tenants.	-
Warmer Ways to Better Health	2005-present	Public Health Agency-funded programme run in conjunction with Antrim and Newtownabbey, Mid and East Antrim, Causeway Coast and Glens, and Mid Ulster councils to support households in fuel poverty through energy efficiency advice and fuel purchasing schemes.	-
Northern Exposure	Ongoing	Public Health Agency-funded programme, managed by NEA Northern Ireland. Promotes energy efficiency services to tackle heating and insulation problems of low-income households by working in partnership with statutory, community and voluntary organisations.	-
Keep Warm Pack Scheme	Ongoing	Public Health Agency-funded programme of warm clothing distribution, targeted and coordinated with the support of a range of cross-sector partners. 7,121 packs were distributed during 2018/19.	-
Belfast Warm and Well Project	Ongoing	NEA programme offering advice and practical support to stay warm and well.	-
Northern Ireland Energy Advice Line	Ongoing	Provides energy advice to householders plus referrals to energy grants and other sources of help. Funded by the Department for Communities. Managed by Bryson Energy until end March 2020, now being delivered by NIHE.	-
Schools Energy Efficiency Awareness Programme (SEEAP)	Ongoing	Increases awareness of energy use through presentations and activities at schools. Delivered by the NIHE and funded by DfC.	-

A3.2.1 Northern Ireland Sustainable Energy Programme (NISEP)

NISEP (formerly the Energy Efficiency Levy) is a customer levy with 80% of funds targeted at providing vital energy efficiency measures to low income households. The scheme was recently extended to 2024.

Policy lever type: Funding (in the form of a grant).

Objective: The policy lever held strategic objectives to contribute to the achievement of efficiency in the use of energy, socially and environmentally sustainable long-term energy supplies and the provision of these objectives at best value to customers with due regard to vulnerable customers. No specific, measurable, achievable, relevant and time-bound (SMART) objectives appear to have been set.

Tenure: Privately-owned domestic and privately-owned non-domestic buildings. NISEP also funds energy efficiency measures in social housing through the landlord, and is available in the private rented sector if the tenant meets specific criteria.

80% of the funding allocation is ring-fenced for vulnerable customers; 40% of the NISEP funds are ring-fenced for priority domestic 'whole house solution' schemes and 40% is allocated to other schemes such as priority domestic 'individual measures'. Within the 20% remaining, 10% is allocated to conventional schemes and 10% innovative schemes. The conventional 10% has a new ring-fence of 7.5% for commercial schemes and 2.5% for non-priority domestic schemes.

Measures: In the domestic categories, whole-house solutions and individual measures offered for domestic customers, including heating systems (gas or oil), cavity wall insulation, loft insulation, hot water tank jackets, LED lighting (including dimming and movement detection options) and heating controls. Non-domestic schemes typically provide a grant of around 20%, and tend to focus on one specific measure such as energy efficient lighting, heating controls or the installation of technology such as variable speed drives or variable speed compressors.

Delivery mechanism: Administered by the Utility Regulator (responsible for regulating electricity, gas, water and sewerage industries in NI) through the Energy Savings Trust (EST). Funding schemes are managed and provided by energy contractors and suppliers. Organisations must register to become a 'Primary Bidder' and then bid for funds with a key metric being cost effectiveness (energy saved per pound spent). There are currently 10 Primary Bidders who are awarded funds based on cost effectiveness of their proposed schemes. For the next round (the 2020-21 NISEP year) a call for schemes was issued in September 2019. Successful schemes will be implemented between 1 April 2020 and 31 March 2021.

Funding pathway: Funded through energy bills which is administered through the Utility Regulator. This comprises approximately £8 million per year collected through all electricity customers through a flat per kilowatt-hour charge added to the NIE Networks Public Service Obligation (PSO) and used to provide funding for energy efficiency schemes across NI.

Challenges: In the priority sector (for vulnerable customers), the majority of funding goes to heating systems, cavity wall and loft insulation and it is often difficult to identify properties which require a whole house solution package (which would be more cost-effective) due to a piecemeal approach to measures and a lack of desire for the full package which tends to result in more disruption (Utility Regulator, 2019).

The majority of funding goes to the priority sector (usually around 90%, exceeding the 80% target) but energy savings in non-priority tends to be more cost-effective. Uptake by non-domestic has been challenging, therefore it's considered that a balance must be struck between vulnerable customers and business (Ibid.).

Effectiveness: NISEP has consistently delivered high lifetime customer benefits since 2010, often more than 10 times the funding spent (Utility Regulator, 2019). Between 2010 and 2017

NISEP provided lifetime energy savings of 4.9 TWh, with associated funding spend of £54 million (Ibid.). During the same time, over 12,000 heating systems were installed in vulnerable homes with total priority vulnerable consumers benefitting from over 300,000 energy saving measures (Ibid.). 65,000 homes benefitted during the same period.

Cost effectiveness: Most of the funding was provided to vulnerable homes which is less cost-effective. In 2016/17, spend equated to £70 per lifetime tonne of carbon saved or £12,500 per lifetime GWh of energy savings. In total between 2010 and 2017, this equates to £60 per lifetime tonne of carbon saved and £11,000/GWh and £800/home (based on figures from (Utility Regulator, 2019)).

Summary of NISEP	
Were SMART objectives set?	No – objective to improve energy efficiency and with due regard to vulnerable customers.
Were the objectives met?	NISEP has contributed to delivery of energy efficiency improvements and has exceeded targets for priority sector.
Lessons learnt	NISEP has a domestic (priority) and non-domestic element but uptake by non-domestic has been challenging.

A3.2.2 Warm Homes Scheme

The Warm Homes Scheme ran between 2001 and 2015 and was a targeted scheme to address fuel poverty amongst vulnerable owner-occupiers and private-rented households (those in receipt of qualifying benefits), through the provision of grants for energy efficiency measures.

Policy lever type: Funding (in the form of grants).

Objective: Original objective to eliminate fuel poverty amongst vulnerable households by 2010 in accordance with the Department for Social Development's Ending Fuel Poverty strategy.

Tenure: Domestic: owner-occupiers, private-rented (excludes social-rented housing sector).

Measures: Home insulation measures including cavity wall and loft insulation, hot water tank jackets and new (oil or gas) heating systems.

Delivery mechanism: The scheme was overseen by the Department for Social Development, and its management was delegated to Eaga plc (and later H&A and Bryson) which was responsible for marketing, administration and delivery of measures by its subcontractors. The NIHE performed some functions, making payments to Eaga under the contract and provided quality assurance on works carried out. Rather than means-tested eligibility, if a household was in receipt of certain benefits, they were eligible. Eaga promoted the scheme to generate enquiries, followed by a discussion for eligibility and a surveyor. EERs were measured before and after the interventions.

Funding pathway: Funded by Department for Social Development. Expenditure of £98.2m between 2001 and March 2008 (including £12.5m fees to Eaga, the scheme manager, £85.7m on energy efficiency measures and £10.8m on NIE).

Challenges: Some of the qualifying benefits were not means-tested and were therefore targeted at vulnerable rather than specifically households experiencing fuel poverty. This approach was said to exclude significant numbers of fuel poor; have simplistic performance monitoring; include measures not sufficient to lift households out of poverty; and increase scheme costs. Independent quality assurance has raised concerns about quality of works (Northern Ireland Audit Office (NIAO), 2008). The scheme also relied on self-selection which made promotion and targeting important (Walker *et al.*, 2012).

Effectiveness: Assisted 120,000 households at a cost of £150m between 2001 and 2015 (Bryson Energy, 2015). It was a popular scheme with customers. Whilst it went some way in contributing to a reduction in fuel poverty, fuel poverty was not eliminated under this scheme. NIAO reported that 30% of investment from Warm Homes had been directed towards households not in fuel poverty.

Cost effectiveness: Total average expenditure equated to £1,631 per household (Northern Ireland Audit Office (NIAO), 2008). Using the Bryson Energy figures above for the period 2001 to 2015, the average cost per household was £1,250.

Summary of the Warm Homes Scheme	
Were SMART objectives set?	Yes – original objective to eliminate fuel poverty amongst vulnerable households by 2010.
Were the objectives met?	The scheme did not eliminate fuel poverty.
Lessons learnt	Approach excluded significant number of fuel poor households, had simplistic performance monitoring, did not include measures significant to lift households out of fuel poverty. Concerns were raised over quality of works. Scheme relied on self-selection.

A3.2.3 Affordable Warmth Scheme

The Affordable Warmth Scheme was launched in September 2014 (NIHE, 2018). It is a targeted scheme to tackle highest fuel poverty households through the funding of energy efficiency measures. The scheme is the successor to the Warm Homes scheme.

Policy lever type: Funding (in the form of grants).

Objective: To target vulnerable households living in fuel poverty. The scheme follows the Fuel Poverty Strategy 'Warmer Healthier Homes' which provided a commitment to improve partnership working and explore an area-based approach. No SMART objectives are apparent.

Tenure: Privately-owned domestic properties. Landlords must make a 50% contribution to the total cost of the energy efficiency measures to improve their property (previously 100% grant was awarded to landlords).

Measures: Available measures are grouped into insulation / ventilation / draught proofing, heating (replacement of heating system or boilers), windows (replacement of single/double glazed windows and solid wall measures (solid wall insulation).

Delivery mechanism: Delivered by NIHE and district councils on behalf of the Department for Communities (DfC). DfC provides targeted addresses to district councils who then contact those households who have been identified as being most likely to be experiencing fuel poverty and be eligible for the Scheme. Option for self-referral also available. Grant of up to £7,500 available per household. Unlike the Warm Homes scheme, the EER is not measured before and after the interventions.

Funding pathway: The NIHE and district councils deliver the scheme on behalf of Department of Finance. The NIHE deliver the scheme through annual KPI targets agreed with DoF and in line with allocated budget for the scheme.

Challenges: A number of challenges were raised through a consultation period to improve the scheme (Ibid.). This included:

- The presence of multiple installers for different measures makes it difficult for households to manage and understand. 'Hand holding' is an important part of the scheme.
- A stepped income threshold would be fairer to households with more than one occupant than the current single income threshold. Further, disability allowance and other allowances not currently included when calculating household income.

Effectiveness: A total of 4,148 homes were improved through the scheme, including over 8,000 interventions in the year 2017/18 (NIHE, 2018). The scheme actively identifies areas where vulnerable people in poorest housing are most likely to live, drawing on district council knowledge.

Cost effectiveness: Average spend per household based on data gathered until 2017 was £4,500 (Department for Communities, 2017). In 2017/18 £17 million of works in private sector homes took place (NIHE, 2018).

Summary of Affordable Warmth Scheme	
Were SMART objectives set?	No – scheme objective was to target vulnerable households living in fuel poverty.
Were the objectives met?	Scheme is considered to be a success in assisting households living in fuel poverty.
Lessons learnt	Multiple installers for different measures made it a complicated process for customers to understand. A stepped income threshold would allow better targeting of households living in fuel poverty.

A3.2.4 Energy Efficiency Loan Fund (EELF)

The EELF launched in the financial year 2003/04 providing loans of between £3,000 and £400,000 to businesses for investing in energy efficient equipment and/or renewable technologies. The scheme is now closed. It was administered by Invest NI and became part of the Sustainable Development Support Programme (SDSP).

Policy lever type: Funding (in the form of loans).

Objective: No SMART objectives but the following are considered by Invest NI to be of relevance (Invest Northern Ireland and Cogent, 2016):

- Increase the number of businesses that implement resource efficiency projects that result in cost savings and/or increased turnover;
- Improve the productivity, competitiveness and sustainability of businesses in NI through the identification and realisation of cost saving opportunities in the use of energy;
- Increase businesses' understanding of the role of energy efficiency in contributing to their growth, development and sustainability; and
- Enhance businesses' commitment to embedding energy efficiency within their longer-term strategy and operations.

Tenure: Non-domestic private ownership.

Measures: Building technologies (including insulation, air conditioning, heating, lighting), industrial process technologies (including compressed air, process controls), and renewables (such as biogas, biomass, air/ground source heat pumps).

Delivery mechanism: The scheme was managed and administered by an external delivery organisation, the Carbon Trust, on behalf of Invest NI. Delivered under a suite of interventions including Carbon Trust's Solutions Activity, Sustainable Productivity Programme and Sustainable Development Support Programme. Invest NI is part of the DfE and provides support for businesses by effectively delivering the Government's economic development strategies (Ibid.).

Funding pathway: The Carbon Trust received applications and sent requests for funding (in the form of 'business plans' to Invest NI). Invest NI then provided Carbon Trust with funding,

on an annual basis, to 'inject' the loan fund for the purposes of offering interest-free loans. Circa £4.5m was 'injected' into revolving EELF between 04/2010 and 12/2015 with a total value of circa £23m. The value of a loan is based upon a project's anticipated annual cost and CO_2 savings. For every 1.5 tonnes of carbon dioxide (CO_2) savings identified through an energy project, a business is eligible for a loan of £1,000 (Ibid.).

Challenges: No dedicated marketing budget. One reference (Invest Northern Ireland and Cogent, 2016) found that this did not to adversely impact demand for loans, however, a later report (Regeneris Consulting and CAG Consultants, 2018) found weaknesses relating to the profile of SDSP services on the Invest NI website, the limited use of case studies and limited use of social media.

Business networks, for example Energy Efficiency Networks (EENs), were recommended (Ibid.) as a means of disseminating information and advice to businesses and encouraging self-help.

Effectiveness: The scheme was launched to support businesses to fund technology and equipment and considered to be effective in doing so based on the below. Taking deadweight into account, net additional lifetime CO_2 savings are expected to be 443,000 tCO_2 with net additional lifetime energy cost savings at £72m – considered to be value for money (Ibid.). A survey of participants found that almost two-thirds stated additional benefits including enhanced human capital and space utilisation, and increased number of contracts won (Ibid.).

Following a period of low demand for loans, the EELF was suspended in June 2018, four months short of the expected operational period. At that point, the EELF had made 428 loans worth £9.63 million compared to the 3-year target of 555 and loans worth £12.49 million (Ibid.). It was suggested that extending eligibility to new build properties could increase take-up. Anecdotal evidence suggests that the cessation of other support, such as Feed-In Tariffs (FiTs) for solar PV, and Renewable /heat Incentive (RHI) for biomass boilers resulted in a reduced demand for EELFs since the desired payback times were no longer perceived to be achievable for these technologies.

Cost effectiveness: EELF activity up to Dec 2015 was expected to return at least £2.10 for every £1 of full economic cost. This equates to £77/tCO_2 spent and an approximate cost of £32,500 per business (Invest Northern Ireland and Cogent, 2016). Analysis of evidence by the end of 2017 indicated that beneficiaries accessing energy efficiency loans are expected to generate return on investment in the region of £18 GVA (gross value added) for every £1 invested by Invest NI (Regeneris Consulting and CAG Consultants, 2018).

Summary of Energy Efficiency Loan Fund	
Were SMART objectives set?	No – but generally aimed to support businesses in improving their energy efficiency.
Were the objectives met?	Considered to be effective in meeting this aim.
Lessons learnt	No dedicated marketing budget which limited ability to communicate information about the scheme effectively.

A3.2.5 Resource Efficiency Capital Grant (RECG)

The RECG provides grants of up to a maximum of £40,000 to Invest NI account-managed companies for the installation of new equipment that provide greater efficiency in the use of water and raw materials, reducing associated waste and hence providing costs savings. The grant scheme is managed by the Energy and Resource Efficiency team within Invest NI.

Policy lever type: Funding (in the form of grants).

Objective: The scheme was devised as part of the SDSP package of support to overcome information failures and asymmetry, externalities and risk aversion.

Tenure: Non-domestic private ownership.

Measures: Installation of new equipment that provides greater efficiency including efficient weighing and cutting machinery and energy from waste recovery.

Delivery mechanism: The grant scheme is managed by the Energy and Resource Efficiency team within Invest NI. The sider SDSP programme received funding approval for £7.82 million for the period October 2015 to September 2018. Of this, capital funding of £1.75 million was allocated to the RECG strand.

Funding pathway: Applications are made in response to calls for applications by Invest NI. Applications are assessed by an internal panel within Invest NI based on fixed criteria and can either be awarded, rejected, or held on reserve. Only Invest NI client companies are eligible, and the majority (86% as at December 2018) were referred by Invest NI client representatives.

Challenges: There was some feedback in the SDSP evaluation survey. This pointed towards the RECG spreadsheet being poorly laid out and difficult to use, possible benefit from simplifying the application process with a clearer set of success criteria stated, and provision of more constructive feedback on unsuccessful applications.

Effectiveness: RECG over-delivered against its target (for number of grants awarded) for years one and two: 28 and 53 grants awarded in 2015/16 and 2016/17 respectively. This totalled £1.24 million of grants levering a total investment of £3.25 million (Regeneris Consulting and CAG Consultants, 2018). However, in those years the programme under-spent against its planned expenditure target, primarily due to the average grant awarded being significantly lower than initially forecast.

Cost effectiveness: RECG grants were popular between October 2015 and September 2017 with 81 grants awarded against planned number of 33 for this period. However, evidence points to modest economic impact, due to limited additionality, in some instances. Discussions with consultees and scheme applicants suggested that this grant rate could be reduced, perhaps from 40 to 20-25% without deterring full uptake (of the available funding) (Regeneris Consulting and CAG Consultants, 2018). The new RECG programme began in October 2019 with 30% as the upper limit for grant intervention.

Analysis of evidence by the end of 2017 indicated that beneficiaries accessing RECG are expected to generate return on investment in the region of £2.77 GVA (gross value added) for every £1.00 invested by Invest NI (Regeneris Consulting and CAG Consultants, 2018).

Summary of the Resource Efficiency Capital Grant	
Were SMART objectives set?	Part of a programme with aims to overcome market failures. There are planned numbers of grants and expenditure for delivery years.
Were the objectives met?	The scheme overdelivered against its target for number of grants awarded but under-spent against expenditure target.
Lessons learnt	The application process was said to be complicated and could be improved upon.

A4 Energy efficiency in other geographies

The literature review has focused on providing an evaluation of energy efficiency policy levers in NI and other geographies, as agreed with the DfE. This section of the report provides a summary of each geography and the policy levers we have focused on. This information will feed into an evaluation of policy lever effectiveness, which will include a comparison of how key factors such as powers and responsibilities work to influence the effectiveness of policy levers across geographies.

Table 29 sets out the policy environment in each of these geographies and enables comparison with that of NI. Table 30 presents building tenure types addressed by policy levers presented in this section.

Table 29: Comparison of characteristics across regions

	NI	RoI	UK	Scotland	Germany	Wales	The Netherlands
Responsibilities and powers relevant to energy efficiency	DfE - overall responsibility for energy policy and economy; DfC - responsibility for fuel poverty and domestic housing stock; DoF - responsibility for building regulations, energy performance certification and inspections and energy efficiency promotion in the public sector; Invest NI is responsible for promotion of energy efficiency in the industrial and commercial sector.	The Energy Efficiency and Affordability Division in the Department of Communications, Climate Action and Environment (DCCAE) is responsible for drafting and implementing policy measures to help RoI reach a target of a 20% improvement in energy efficiency by 2020.	The Department for Business, Energy and Industrial Strategy (formerly Energy and Climate Change) is responsible for the design, implementation and management of energy policy in the UK, although energy efficiency is a devolved matter. The Ministry of Housing, Communities and Local Government has responsibility for building regulations, energy performance certificates and inspections.	The Scottish Government leads on the promotion of energy efficiency programmes. The regulation of energy efficiency sits with the UK Government.	The Germany Federal Government is responsible for setting the agenda relating to energy efficiency.	The Welsh Government leads on the promotion of energy efficiency programmes. The regulation of energy efficiency sits with the UK Government.	Dutch Government through policy and Climate Agreement, supported by multiple stakeholders (municipal and provincial authorities, housing corporations, energy companies, business associations, citizen groups, water boards).
Role of local councils in energy efficiency delivery	District councils have a role in reducing fuel poverty, for example, through the delivery of the Affordable Warmth Scheme. Also responsibility for building control through enforcement of NI building regulations. Energy efficiency measures can be required through the planning process. Councils' community plans also consider energy matters.	Some local authorities have introduced building energy standards as part of planning requirements.	The local authorities have the powers to require energy efficiency of new buildings as part of the planning process and some support retrofit schemes through accessing grants.	Local authorities have Local Heat and Energy Efficiency Strategies (LHEES) and a budget to reduce emissions from buildings and tackle fuel poverty.	The energy performance of new buildings is checked by the local authorities, who are also in charge of a penalty system.	Local authorities have powers to implement energy efficiency through their local development plans.	Local authorities have a subsidy scheme to provide a budget to implement energy efficiency and climate policy.

	NI	RoI	UK	Scotland	Germany	Wales	The Netherlands
Fuel poverty (note that definitions vary in and between regions)	22% of households in 2016, having decreased from 42% in 2011. Fuel poverty calculation is dependent upon oil prices and this figure was taken at a point in time when fuel prices had been averaging relatively low. A household is deemed to be in fuel poverty if it needs to spend more than 10% of household income on fuel.	9% of individuals unable to afford to keep the home adequately heated (SEAI, 2018).	In England, 10.9% of households in 2017 (BEIS, 2019d). A household is in fuel poverty if their income is below the poverty line and their energy costs are higher than is typical for their household type.	25% of households (BEIS, 2019d). A household is deemed to be in fuel poverty if it needs to spend more than 10% of household income on fuel.	17% of private households (Heindl and Loeschel, 2014) A household is deemed to be in energy poverty if it cannot afford to pay its energy bills.	12% of households (BEIS, 2019d), corresponding to 155,000 households. A household is deemed to be in fuel poverty if it needs to spend more than 10% of household income on fuel.	6.6% of all households (Thomson and Snell, 2013)
Fuel use in homes	High use of oil (68% of homes) compared to only 25% using mains gas in 2016 (Utility Regulator, 2019). High use of oil is due to limited gas infrastructure across rural areas in NI.	Most common dwelling is detached house, typically located in rural areas and reliant on solid fuels or oil-based heating systems (SEAI, 2018). High use of oil is due to limited gas infrastructure across rural areas in RoI.	5% of consumers heated homes using oil and 85% using mains gas in 2018 (DfE, 2018). Mains gas is widely available throughout Great Britain which makes it the main type of central heating at the UK level.	Majority of households use mains gas for their heating, with smaller proportions using electricity and oil as their main fuel source (Scottish Gov., 2018).	Number of oil-fired boilers used expected to fall due to increase in heat pumps and district heating installations in new homes. Gas-fired boilers used in 26.8% of homes. (Federal Ministry for Economy Affairs and Energy, 2015)	17% of Welsh properties are off the gas grid and rely on more expensive LPG, oil or electricity for heating.	Currently 95% of buildings in the Netherlands are heated by natural gas.
Tenure split	Owner Occupied 63.4%; Private Rented and Others 17.4%; Social Housing 15.5%; Vacant 3.7% (NIHE, 2019b).	Ownership of residential housing stock – high proportion of owner occupied (68%) versus private rented (18%) and local authority rented (8%). (SEAI, 2018).	In England, 64% dwellings owner occupied, 30% privately rented, 7% social rented (MHCLG, 2020) Scotland, Wales, and NI are set out in other columns in this table.	Approximately 61% of homes are owner occupied, 15% are privately rented, and 23% are socially rented. (Scottish Gov., 2018)	51.5%. owner occupied, 40.8% rent at the market price, 7.7% rent at a reduced price or free (European Commission, 2020b).	6% of homes are owned by Local Authorities, 10% by Registered Social Landlords, 70% are owner occupied and 15% are privately rented (StatsWales 2019).	68.9%. owner occupied, 30.2% rent at the market price, 1.0% rent at a reduced price or free (European Commission, 2020b).

	NI	RoI	UK	Scotland	Germany	Wales	The Netherlands
Housing stock	Approximately 780,000 dwellings in 2016 (NI House Condition Survey 2016)	Approximately 1.6m dwellings (SEAI, 2018).	In England, 23.9m dwellings in 2017 (MHCLG, 2017)	Around 2.7m properties. In 2016 around 2.5m of these were domestic properties. Therefore, 200,000 non-domestic buildings (Scottish Gov., 2018).	More than 30% of buildings in Germany are non-residential (Schlomann and Eichhammer, 2012)	The Welsh housing stock comprises 1.4m properties (StatsWales 2019).	The Dutch housing stock comprises 7.8m properties (Opendata.cbs.nl 2019)

Table 30: Building tenure types addressed by each policy lever

Policy lever		***Status: ongoing lever***	***Tenure type***				
			Owner-occupied	*Privately rented*	*Social housing*	*Non-domestic (public)*	*Non-domestic (private)*
Northern Ireland	NISEP	✓	✓	✓	✓		✓
	Warm Homes Scheme		✓	✓			
	Affordable Warmth Scheme	✓	✓	✓			
	Energy Efficiency Loan Fund						✓
	Resource Efficiency Capital Grant scheme	✓					✓
UK	Minimum Energy Efficiency Standard (MEES) - *England and Wales*	✓		✓			
	The Green Deal – *Great Britain*		✓	✓	✓		
	Carbon Emissions Reduction Target (CERT) – *Great Britain*		✓	✓	✓		
	Community Energy Savings Programme (CESP) – *Great Britain*		✓	✓	✓		
	Energy Company Obligation (ECO) – *Great Britain*	✓	✓	✓	✓		
RoI	Better Energy Homes (BEH) grant scheme	✓	✓	✓			
	Deep Retrofit Pilot Scheme	✓	✓	✓			
Scotland	HEEPS: Warmer Homes Scotland	✓	✓	✓	✓		
	HEEPS: Area-based schemes	✓	✓	✓			
	Energy Efficiency Scotland (EES) pilot projects	✓	✓	✓		✓	✓
	Energy Efficient Standard for Social Housing (EESSH)	✓			✓		
Germany	Energy Efficiency Networks Initiative	✓					✓
	CO_2-Building Rehabilitation Programme (CBRP)		✓	✓			
	Special fund for energy efficiency in SMEs	✓					✓
	Minimum Standards for New and Refurbished Buildings (EnEV 2009)	✓	✓	✓	✓	✓	✓
Wales	Warm Homes Nest scheme	✓	✓	✓			
	Warm Homes Arbed scheme	✓	✓	✓			
The Netherlands	Climate Agreement	✓	✓	✓	✓	✓	✓
	Energiesprong/Stroomversnelling	✓	✓	✓	✓		
	Energy-saving at Home subsidy scheme (SEEH)	✓	✓				
	The Sustainable Energy Investment Grant (ISDE)	✓	✓				✓
	Incentive scheme for energy performance in the rental sector (STEP)			✓	✓		
	Energy Investment Allowance (EIA) for landlords	✓					✓

A4.1 United Kingdom

The UK's Energy Efficiency Strategy (Department of Energy & Climate Change, 2012) was published in 2012 and was shortly followed by an update to the strategy in 2013 (DECC, 2013). The 2013 Update sets out the UK Government's progress in delivering a programme of action and support on energy efficiency across homes, businesses and the public sector. The Government's approach to energy efficiency, as set out in the Strategy, is led by four key barriers to energy efficiency take-up: embryonic markets, information, misaligned financial incentives and undervaluing energy efficiency.

This section provides an overview of a range of policy levers which have been implemented across the UK, as indicated in the table below. The promotion of energy efficiency in Scotland and Wales is devolved, however, the regulation of energy efficiency remains with the UK Government. In NI, both the promotion and regulation are devolved to the NI government.

Table 31: Energy efficiency policy levers in the UK

Policy lever	**Applicable dates**	**Summary**	**Further detail**
Building Regulations *UK*	Ongoing	Minimum standards to which the erection, extension, or material alteration of buildings must adhere.	A4.1.1
Minimum Energy Efficiency Standard (MEES) *England and Wales*	2018 – present	Set a minimum energy efficiency level for domestic private rented properties and non-domestic private rented properties.	A4.1.2
The Green Deal *GB*	2013 – 2015 government led 2017 – present privately funded	The Green Deal is a finance mechanism for the able-to-pay market to deliver retrofits without the need for public subsidies.	A4.1.3
Carbon Emissions Reduction Target (CERT) *GB*	2008 – 2012	CERT was a supplier obligation scheme which placed an obligation on the six major gas and electricity suppliers to meet a target for reducing carbon emissions.	A4.1.4
Community Energy Saving Programme (CESP) *GB*	2009 - 2012	CESP was a supplier obligation scheme which placed an obligation on certain gas and electricity suppliers to reduce energy efficiency measures to domestic users, with a focus on deprived areas.	A4.1.5

Policy lever	Applicable dates	Summary	Further detail
Energy Company Obligation (ECO) *GB*	2013 - present	ECO is a supplier-led scheme which provides grants to households, funded through energy bills. It was refocused in 2018 towards low income, vulnerable and fuel poor households.	A4.1.6
Energy Performance Certificates (EPCs) *UK*	2007 – present	EPCs are reports that assesses the energy efficiency of a property and recommends specific ways in which the efficiency of your property could be improved. They are required when a property is built, sold or rented.	A4.1.7
Display Energy Certificates (DECs) *UK*	2008 – present	DECs provide an energy rating of the building based on the actual amount of metered energy used by the building.	A4.1.8
Energy Savings Opportunity Scheme (ESOS) *UK*	2015 – present	ESOS is a mandatory energy assessment scheme for organisations in the UK that meet qualifying criteria. Audits are required every 4 years of energy used by buildings, industrial processes and transport to identify cost-effective energy efficiency measures.	-
CRC Energy Efficiency Scheme *UK*	2010 – 2019	The scheme applied to ‘large’ energy users in the public and private sectors across the UK, including supermarkets, water companies, banks, local authorities and all central government departments. Organisations that consumed over 6,000 MWh of electricity per year were required to buy allowances for every tonne of carbon emission.	-
Streamlined Energy and Carbon Reporting (SECR) *UK*	2019 - present	All quoted companies and large UK incorporated unquoted companies disclose Scope 1 and Scope 2 UK energy consumption (kilowatt-hours of fuel combusted, and electricity used); and measures taken to increase the company’s energy efficiency.	-

Policy lever	Applicable dates	Summary	Further detail
Smart metering and billing *GB*	2007 - present	The rollout of smart meters is being led by BEIS and Ofgem in two stages. The first phase involved engagement with the energy industry, consumers and stakeholders, and the second phase is the roll-out.	-
Climate Change Levy *UK*	2001 - present	Energy producers and suppliers are required to pay tax on energy delivered to non-domestic users in the industry, commerce and public sector. The revenue is recycled to business through cuts in National Insurance Contributions and support for energy efficiency schemes.	-
Climate Change Agreements *UK*	2001 - present	Climate Change Agreements provide a part exemption from the Climate Change Levy for businesses within certain energy-intensive sectors, and tax discounts for sectors that agree to energy efficiency targets.	-
Energy Entrepreneurs Fund *UK*	2012 – present	A funding scheme to support the development and demonstration of innovative technologies, products and processes in the areas of energy efficiency, power generation and heat and electricity storage.	-
Green Business Fund *GB*	2016 – 2019	The Carbon Trust Green Business Fund supported small to medium sized organisations (SMEs) in England, Scotland and Wales, providing opportunities to improve energy efficiency. Includes energy opportunity assessments, and implementation and equipment procurement advice. The grant element of this programme was originally 30%, up to a maximum of £10,000 total expenditure. However, this was reduced one year into the programme (in 2017) to 15% up to a maximum cost of £5000, reportedly owing to the high levels of demand (Regeneris Consulting and CAG Consultants, 2018).	-

Policy lever	Applicable dates	Summary	Further detail
Salix Finance *GB*	Ongoing	Salix Finance is an independent, not for profit, organisation that provides access to interest-free government funding to local government, schools, NHS, and further, and higher education institutions in England, Scotland and Wales.	-
Industrial Heat Recovery Support programme (IHRS) *England and Wales*	2019 – 2022	The BEIS IHRS programme is helping businesses to identify and invest in opportunities for recovering and reusing heat that would otherwise be wasted. Funding is available for feasibility (up to 50%) and design (up to 30%). From Autumn 2018 to March 2022, £18 million will be available over 2 phases.	-
Industrial Energy Transformation Fund (IETF) *England, Wales, and Northern Ireland*	Launched July 2020	The BEIS IETF programme is a £289 million fund for: 'mature' energy efficiency technologies; and 'deep decarbonisation technologies' which include industrial carbon capture, low-carbon fuel switching, and material efficiency.	-
Industrial Energy Efficiency Accelerator (IEEA) *UK*	The second phase launched Feb 2019 and ran until 30 Apr 2019.	IEEA helps to identify new energy efficient technologies and accelerate their deployment in UK industry. Industrial and manufacturing sectors in the UK are eligible.	-
Enhanced Capital Allowances (ECA) *UK*	2001 – present	The ECA scheme enables businesses to claim 100% first-year capital allowance on investments in energy-saving equipment. Therefore, ECAs provide accelerated tax relief resulting in cash flow benefits compared to standard capital allowances.	-
Kirklees Warm Zone *England local authority*	2007 - 2010	Scheme provided free loft and cavity wall insulation to more than 50,000 properties. Aimed to tackle fuel poverty and reduce direct carbon emissions while focusing on simple technology which enabled the training of local community members to conduct the works. Led by local authority.	-

Policy lever	Applicable dates	Summary	Further detail
RE:NEW *England, London only*	2009 - 2016	A pan-London home energy retrofit programme delivered by the Greater London Authority (GLA) in partnership with London boroughs, London Councils and the Energy Saving Trust. It was co-funded by the European Investment Bank and GLA. It aimed to reduce CO_2 emissions from energy consumption in the domestic sector at scale and in a cost-effective manner using an area-based delivery model bringing most of London's home energy retrofit activities into a coherent programme.	-
RE:FIT *England, London only*	2009 - 2024	A pan-London non-domestic energy retrofit programme targeting London's state-owned buildings. The scheme is part funded by the European Regional Development Fund (ERDF) and is delivered by the GLA in partnership with a selected group of established service providers. It aims to support a range of organisations including NHS bodies, schools, universities and cultural and heritage organisations by providing impartial advice, to securing funding and supporting the tender process.	-
Retrofit Accelerator – Homes *England, London only*	2020 – present	Part funded by the ERDF, the £3.6m fund provides insulation and low carbon heat and power solutions for homes. The programme will provide London boroughs and housing associations the technical expertise they need to kick-start 'whole-house' retrofit projects across the capital.	-

A4.1.1 Building Regulations

UK Building Regulations are statutory instruments or rules, meaning that they are laws made by an executive authority under powers delegated by primary legislation.

The Building Regulations are a set of minimum standards to which buildings must adhere, and include setting standards for the energy performance of new and existing buildings. The standards apply to the erection, extension, or alteration of buildings.

People who are responsible for building work (for example, the agent, designer, builder or installer) must ensure that the work complies with all applicable requirements of the Building Regulations. The building owner may also be responsible.

Building regulations in **England** are the Building Regulations 2010 and (Amendment) Regulations 2013. Guidance comprises 16 separate groups of documents, with Part L (Conservation of fuel and power) relevant to energy efficiency. Part L is split into four sections: L1A New dwellings; L1B Existing dwellings; L2A New buildings other than dwellings; L2B Existing buildings other than dwellings.

The UK Government has committed to introducing a Future Homes Standard for new build homes by 2025, which will be implemented through the Building Regulations. The consultation (MHCLG, 2019b) published in October 2019 sets out the Future Homes Standard for **England** only, including proposed options to increase the energy efficiency requirements for new homes in 2020. The consultation sets out options to uplift energy efficiency standards and requirements, to achieve either a 20% or 31% reduction in carbon emissions compared to the current standard. It is expected that the 20% option would be delivered predominantly by very high fabric standards, including triple glazing. The 31% option would typically be delivered through a minor increase to fabric standards (for example double rather than triple glazing), alongside use of low-carbon heating and/or renewables, such as photovoltaic panels. The government states that both options deliver a greater improvement in carbon emissions than the former Zero Carbon Homes policy. However, the proposals have been criticised with claims that the use of energy efficient heating systems could mask relatively poor fabric performance, and the proposed use of carbon and primary energy factors disguise the energy efficiency of a home (London Energy Transformation Initiative, 2020).

For **Scotland**, the relevant legislation is the Building (Scotland) Regulations 2004. Technical handbooks provide guidance in two volumes, for domestic buildings and non-domestic buildings.

The Welsh Government is the responsible body for Building Regulations in **Wales**; the Building regulations 2010 and (Amendment) (Wales) Regulations 2014. The regulations are similar to those for England, comprising 16 separate groups of documents, with notable differences for photovoltaics requirements, lighting efficacy, and air permeability. The Welsh Government has consulted on the future of energy efficiency and ventilation within new build homes. Like the proposed Future Homes Standard for England, there are two options described in the consultation. The Welsh options go further, with Option 1 having a 37% reduction in carbon emissions, and Option 2 having a 56% reduction in carbon emissions, compared to the current standards.

For **NI**, conservation of fuel and power is covered in Part F of the Building Regulations with guidance provided by Technical Booklet F1 (dwellings) and F2 (buildings other than dwellings).

NI introduced improvements to energy efficiency standards through Building Regulations in 2012. These improvements have delivered a 25% reduction in CO_2 emission for new buildings and certain extensions, compared with the policy standards set in 2006 (DECC, 2014).

Building regulations in NI are normally revised in light of amendments in England. The current Part F regulations do not reflect the last major uplift from England, made in 2013 and applicable from April 2014, which approximated to a carbon performance improvement of some 6% (for new dwellings) and 9% (for new buildings other than dwellings) when applied to England's new-build mix. In addition, NI offers a generous fuel factor regime such that homes without gas can often be constructed to broadly similar fabric standards to those which

are able to avail of the gas network. Standards for works to existing buildings are largely similar to England, bar some relatively minor efficiency improvements on non-domestic chiller and lighting services.

A4.1.2 Minimum Energy Efficiency Standard (MEES)

Policy lever type: standard

Objective and tenures: MEES regulations establish a minimum standard of EPC band for properties, affecting new tenancies and renewals.

One of the aims of the UK's Clean Growth Strategy (BEIS, 2017) is to get as many homes as possible to EER of C by 2035, where practical, cost-effective and affordable.

The regulations for **England** and **Wales** apply to any privately rented home with an EER of F or G (the lowest bandings). Landlords are obliged to improve ratings to an 'E' or better, unless this cannot be done for £3,500 or less, in which case all improvements which can be made up to that amount need to be made. The Regulations have been amended twice. The most recent amendments introduced a new self-funding element for domestic landlords, which takes effect if landlords are unable to access third-party funding to improve any EPC F or G properties they let to EPC E. This spend element is capped at £3,500 (incl VAT) per property.

For **Scotland**, The 'Energy Efficient Scotland' routemap (Scottish Government, 2018b) outlines forthcoming minimum EPC standards:

- By 2040 **all** Scottish homes achieve an EPC C (where technically feasible and cost effective).
- Maximise the number of **social rented** homes achieving EPC B by 2032.
- **Private rented** homes to ne EPC E by 2022, to EPC D by 2025, and to EPC C by 2030 (where technically feasible and cost effective).
- All **owner-occupied** homes to reach EPC C by 2040 (where technically feasible and cost effective).
- All homes with **households in fuel poverty** to reach EPC C by 2030 and EPC B by 2040 (where technically feasible and cost effective).
- **Non-domestic** buildings will be assessed and improved to the extent this is technically feasible and cost effective by 2040.

Challenges: Local authorities' budgets are strained and there is concern that there is weak enforcement of the MEES regulations (BEIS Select Committee, 2019). It was found that enforcement action by local authorities is limited (RSM, 2019). Some local authorities are developing systems and looking to enforce the regulations within the next year. Others are yet to undertake any work at all around enforcing the MEES. The ineffectiveness of the exemption criteria for the England & Wales legislation (prior to April 2019) was a key barrier to enforcement, along with a lack of resourcing for this activity within local authorities. Local authorities also have other legislation they can use (the Housing Health and Safety Rating System) in order to improve standards in the private rented sector (PRS), and were more familiar with this. It was widely felt that it will be easier to enforce the MEES after April 2020 when the standards apply to existing tenants too (as long as the property has an EPC). However, the practical challenges in identifying non-compliant properties, contacting landlords, and resourcing the activity make it difficult for local authorities to enforce the MEES efficiently.

A4.1.3 The Green Deal

The Green Deal was created as a finance mechanism for the able-to-pay market to deliver retrofits at a large scale without the need for public subsidies. The finance provided was supplemented by broader advice, accreditation and assurance. Between 2013 and 2015 the Green Deal was government-led, however, since 2017 it has been privately-funded.

Objective: The Green Deal was part of two schemes, along with the Energy Company Obligation scheme (ECO), with an aim to improve household energy efficiency to reduce CO_2 emissions whilst achieving other objectives including to stimulate significantly more private investment, improve harder-to-treat properties and mitigate the main cause of fuel poverty. The former UK Department for Energy and Climate Change (DECC) estimated that by 2020 it would have supported the retrofit of 14 million homes. SMART objectives were not set.

Policy lever type: Funding (in the form of loans).

Tenure: Domestic properties – privately-owned and private landlords. Social housing providers could also participate.

Measures: Individual measures and whole-house approach offered – includes insulation (such as solid wall, cavity wall, loft insulation), heating, draught-proofing, double glazing, renewable energy generation.

Delivery mechanism: The Green Deal Oversight and Registration Body (GD ORB), on behalf of DECC/BEIS, manages the scheme and is responsible for the administration and oversight including maintaining a register of all authorised providers, certification bodies, assessors and installers. Green Deal Providers offer Green Deal Plans to customers and arrange installation.

The Green Deal sought to overcome barriers of high upfront costs and uncertain contractor reliability.

Funding pathway: Loans tied to the building rather than the occupant and paid through instalments on electricity bills. Green Deal Finance Company provide private finance to Green Deal providers who in turn agree loans with consumers.

Challenges: The scheme did not include performance monitoring of measures. The loans were subject to high interest rates and therefore had limited appeal. There was a narrow engagement with consumers focussing on cost rather than wider benefits and drivers such as increased comfort, increased wellbeing, and associated health benefits (Rosenow and Eyre, 2016; Brown *et al.*, 2018). Households also derive value from increased aesthetics resulting from renovations (Haines and Mitchell, 2014).

A review of the impact of the Green Deal (Pettifor, Wilson and Chryssochoidis, 2015) found that homeowners think about improving their homes, not about improving energy efficiency. It was found that the policy suffered due to a number of design limitations. Energy efficiency-only renovations were promoted, but the policy would have benefited from targeting the inclusion of energy efficiency measures in all types of major renovation work, and home improvement products and services. The Green Deal should have targeted all potential renovators, not just would-be energy efficiency renovators. The policy would also have benefited from viewing a renovation decision as a series of stages rather than a one-off event, which would have allowed services providers to tailor information, advice and services at different stages.

Effectiveness: DECC estimated that the Green Deal would support 2 million homes by 2020 however only about 6,000 per year were retrofitted. Energy efficiency improvements were actually found to significantly slow down following the introduction of the Green Deal, with the average delivery rate for loft insulation dropping by 90% by 2015 (Rosenow and Eyre, 2016).

Cost effectiveness: DECC spent up to £240 million on the Green Deal up until March 2015. However, this was found not to generate any additional energy savings due to the design of the scheme resulting in a lack of persuasion that energy efficiency measures were worth paying for. The overall cost per tonne of carbon saved by both the Green Deal and ECO (explored further below) was £94. There is uncertainty over cost of scheme per tonne of CO_2 saved. For 14,000 homes that took up Green Deal finance plans, DECC spent an average of £17,000 per home (National Audit Office, 2016).

Summary of the Green Deal	
Were SMART objectives set?	No – aim to improve household energy efficiency whilst achieving other objectives including stimulate private investment, improve harder-to-treat properties and mitigate main cause of fuel poverty.
Were the objectives met?	The scheme did undertake energy improvements but at a significantly lower scale than predicted.
Lessons learnt	Performance monitoring of measures is important. High interest rates do not appeal to consumers. Narrow engagement with consumers – focussing only on cost savings. Scheme did not target all potential renovators.

A4.1.4 Carbon Emissions Reduction Target (CERT)

The Carbon Emissions Reduction Target (CERT) was in place between 2008 and 2012, and was superseded by the Energy Company Obligation (ECO). It was a Supplier Obligation scheme, placing an obligation on the six major gas and electricity suppliers to meet a target for reducing carbon emissions.

Objective: Energy suppliers were required to deliver measures that would provide overall lifetime carbon dioxide savings of 293 $MtCO_2$ by December 2012 by promoting uptake of energy efficiency measures.

Policy lever type: Obligation on energy suppliers.

Tenure: Domestic: privately-owned, private landlords and social housing.

Measures: Not overly prescriptive about measures but included insulation, lighting, heating, microgeneration & CHP, behavioural, demonstration actions and appliances.

Delivery mechanism: DECC was responsible for setting the overall target and designing the statutory programme through which the target was to be achieved. Ofgem was responsible for administering the programme on behalf of the Gas and Electricity Markets Authority. Obligations were imposed on individual energy supply licence holders. Projects such as 'Warmzones' encouraged a multi-agency and area-based approach which involved intensive marketing targeting streets identified as most at risk of fuel poverty (Citizens Advice Scotland, 2016). Partnerships with social housing providers played a big role in delivery (Ofgem, 2013a).

Funding pathway: Funded through a levy on household energy bills. Funding supplemented from sources including householders, local authorities and housing associations.

Challenges: Engagement with vulnerable and hard to reach households – traditional promotion methods were not effective, therefore delivery stakeholders worked with intermediaries, who were often more trusted than energy companies. However, beneficiaries were often not those most in need and the incentive structure encouraged delivery of lowest-cost measures, with the more challenging not prioritised. Integration of other funding schemes also led to complex and inefficient customer journeys (Citizens Advice Scotland, 2016).

Effectiveness: Successfully delivered a significant number of 'quick wins' such as loft and cavity wall insulation. Area-based schemes in particular were found to be effective especially with use of local trusted intermediaries. Monitoring and reporting encouraged understanding of housing stock (Ibid.). By December 2011, CERT had achieved 78% of its CO_2 target and 42% of its insulation target however this still left a challenging number of installations in 2012 (CCC, 2012). By the end of CERT, carbon savings of 297 $MtCO_2$ were achieved, 101% of overall target, although energy companies carried over 13% of this from the previous programme EEC2 (Ofgem, 2013a).

Cost effectiveness: CERT combined with the CESP cost £34/tCO_2.

Summary of Carbon Emissions Reduction Target	
Were SMART objectives set?	Yes – target on energy suppliers to meet target of 293 $MtCO_2$ by December 2012.
Were the objectives met?	Yes – carbon savings of 296.9 $MtCO_2$ were achieved.
Lessons learnt	Delivery undertaken by local intermediaries who were more trusted than energy companies. Area-based schemes in particular found to be effective. Incentive structure encouraged delivery of lowest cost measures. Effective monitoring and reporting encouraged understanding of housing stock condition.

A4.1.5 Community Energy Saving Programme (CESP)

The CESP (2009-2012) was a policy designed to improve domestic energy efficiency standards in the most deprived areas in the UK. It set an obligation on large gas and electricity suppliers and generators to reduce CO_2 emissions by promoting a range of energy efficiency measures to domestic users. The measures were required to be delivered in 'low income areas' as defined by the Indices of Multiple Deprivation tool.

Objective: The overall target was 19.25 lifetime $MtCO_2$. This included a supplier target of 16.63 $MtCO_2$ and a generator target of 2.62 lifetime $MtCO_2$.

Policy lever type: Obligation on energy suppliers.

Tenure: Domestic: privately-owned, private landlords and social housing.

Measures: Designed to deliver a whole house approach. Individual measures offered by energy suppliers and generators to progress towards meeting targets, with bonus for households that implemented two or more. The scheme was designed to encourage installation of a package of measures and more difficult to install measures than those offered under CERT. Measures included insulation, double glazing, draught proofing, heating controls, boiler replacement.

Delivery mechanism: DECC was responsible for setting the overall CESP target and for designing the statutory programme through which this target was to be achieved. Ofgem was responsible for administering the programme, on behalf of the Gas and Electricity Markets Authority. Almost all CESP measures were delivered through partnerships with social housing providers or by direct promotion to private households. The programme was structured in a way which would incentivise energy companies to install specific measures and to encourage numerous measures in each house / area as possible (Ofgem, 2013b). Some measures were incentivised through provision of additional carbon savings i.e. solid wall insulation whereas others were disincentivised i.e. cavity wall insulation. A whole house bonus was applied where two or more measures were completed in one home. Similarly, if 25% of dwellings in a low-income area were treated by the same supplier, an area bonus applied.

Funding pathway: The cost of the obligation was passed on by energy companies to customers through energy bills.

Challenges: Further concentration of activities in particular areas would have allowed companies to take advantage of area bonus. The characteristics of an area may have prevented uptake of area bonus i.e. boundaries of areas not necessarily in line with communities, and the number of social housing providers may have been a deterrent due to complexities setting up multiple contracts and commercial arrangements. Bonuses weren't fully utilised which may explain why some energy companies did not meet their obligations.

Effectiveness: Energy companies achieved 85% against the overall target, saving 16 million lifetime tonnes of CO_2. Suppliers met 92% and generators met 36% of their respective targets (Ofgem, 2013b). In total, 294,000 measures were installed through 491 schemes in 154,000 homes. Incentive structure largely achieved intention, with solid wall insulation and boiler replacements being two of the three most common measures installed – in total, 72% of overall carbon savings were achieved through bonuses. Energy companies were required to undertake monitoring on at least 5% of each measure installed which was a key control in CESP, and properties were inspected.

Cost effectiveness: CERT, combined with the CESP, cost £34/tCO_2.

Note that a rating of 1 has been allocated since CESP did not meet its target, but combined with CERT, and relative to the Green Deal, it could be considered to be a success.

Summary of Community Energy Saving Programme	
Were SMART objectives set?	Yes – overall target of 19 lifetime $MtCO_2$ savings.
Were the objectives met?	Both energy companies and suppliers made significant progress in meeting respective targets although did not achieve overall target.
Lessons learnt	Delivered through social housing providers mostly but bonuses weren't fully utilised likely due to some complexities of delivery.

A4.1.6 Energy Company Obligation (ECO)

The ECO is a supplier-led energy efficiency scheme which provides grants to households funded through energy bills. It is a Supplier Obligation scheme. It was refocused in 2018 towards low income, vulnerable and fuel-poor households.

Objective: Wider government target to improve energy efficiency of one million homes, with ECO one of the schemes to be used to achieve this. Government imposed an energy savings target on energy companies, to be achieved at the customer end. Suppliers must deliver 15% of their ECO measures to homes in rural areas, and 10% of them can be installing 'innovative' products, such as devices to help homeowners manage their energy use.

Policy lever type: Obligation on energy suppliers.

Tenure: Domestic: privately-owned and private landlords.

Measures: Measures mainly relate to insulation (including cavity and internal wall insulation, loft insulation, draught proofing and window glazing), boiler upgrades and heating controls.

Delivery mechanism: Ofgem is responsible for administering and enforcing the energy savings targets. Target set for each energy company who is then responsible for contracting installers of energy saving measures who carry out the words to a defined standard. Energy companies adopted a variety of approaches to engage households. Some were engaged directly but, most commonly, the energy companies contracted this work to installers or managing agents that arranged and/or carried out installations (potentially involving intermediary organisations such as social housing providers). 'Brokerage' was also used – a blind auction platform developed by DECC where installers could sell 'lots' of measures they would then be contracted to deliver to energy companies in return for funding (Citizens Advice Scotland, 2016).

Funding pathway: Funded through energy bills.

Challenges: Initially designed to fund more expensive retrofit measures such as solid wall insulation but was criticised for a focus on single measures and seen to disincentivise comprehensive installations with no funding for complementary work such as ventilation. A

levy is placed on all household bills including those that do not benefit, therefore redesigned to focus on 'fuel poor' (Brown *et al.*, 2018). Suppliers considered to be choosing 'low hanging fruit'. ECO considered to be underfunded and top-up funds are not available to those in fuel poverty.

Effectiveness: Wider government target to improve energy efficiency of one million homes was almost entirely achieved by ECO (as opposed to the Green Deal). 1.4m homes were improved through ECO by December 2015 with 1.7m individual improvements. 33.7m tonnes of CO_2 savings expected over lifetime measures installed by 31st March 2017 (compared to 0.4m through the Green Deal) (National Audit Office, 2016).

Since the ECO scheme started operating in January 2013, and as of December 2018 has delivered around 2.5 million improvements, in around 2 million homes (BEIS & HMT, 2019).

Cost effectiveness: After 2014, changes to ECO where easier-to-treat measures became eligible for funding, ECO cost suppliers £61/tCO_2 (National Audit Office, 2016). In 2017/18 the budget allocated to ECO was £555m (which is £640m less £85m admin costs) (HM Government, 2019).

Summary of the Energy Company Obligation	
Were SMART objectives set?	Yes - objectives were placed on energy suppliers to support the government to meet a target of improving energy efficiency of 1 million homes.
Were the objectives met?	The wider target of 1 million homes was almost entirely achieved by this scheme.
Lessons learnt	Suppliers found to cherry pick easiest measures. Lack of available funding.

A4.1.7 Energy Performance Certificates (EPCs)

EPCs are needed whenever a property is built, sold, or rented. An EPC contains information about a property's energy use, typical energy costs, and recommendations about how to reduce energy use. An EPC gives a property an energy efficiency rating from A (most efficient) to G (least efficient) and is valid for 10 years.

Objective: To raise public awareness of energy use, to encourage uptake of energy efficiency improvements, and to comply with requirements of the EU Energy Performance of Buildings Directive.

Policy lever type: Standards and targets.

Tenure: Domestic, private-rented commercial, and public sector.

Measures: EPCs include recommendations on how the energy efficiency of the property could be improved.

Delivery mechanism: An EPC must be produced when a new building has been constructed; and when a building is to be sold or rented to a new tenant. An EPC must also be obtained and displayed in a building over 250 m^2 in area, which is occupied by a public authority and frequently visited by the public. EPCs are valid for 10 years. They are based on information such as the size and layout of a building, how it has been constructed and the way it is insulated, heated, ventilated, and lighted. Since people use buildings in different ways, the calculation is based on standardised assumptions of occupancy and use.

Funding pathway: A building seller or landlord commissions an EPC or it may be commissioned on their behalf by an agent such as an estate agent. EPCs can only be produced by an accredited energy assessor. Energy assessors may be self-employed or employees of service organisations such as estate agents, conveyancers or energy companies.

Challenges: Possible sources of error could result in an EER not being reflective of the actual performance of the building, and also result in variability between repeat assessments of the same building. Issues that have been identified in relation to EPCs (BEIS, 2018b) are: The EPC for a new building is based on the as-built SAP assessment, but the design does not match construction; Poor information about actual construction of existing buildings; Assessor errors in observing and recording details of the building; Incomplete technology lists and the use of default values.

Effectiveness: UK Government launched a call for evidence on the effectiveness of EPCs (BEIS, 2018b). The consultation is now closed but the outcome has not yet been published.

A review of 14 consumer attitude studies published since 2007 on domestic EPCs suggests that around 80% of people are aware of EPCs, and that 60% found EPCs easy to understand (Backhaus, et al., 2011). However, the recommendations were considered less easy to understand than the rating, and only 17% of homeowners in the English Housing Survey 2011 recalled that the EPC contained recommendations (DCLG, 2013).

Evidence for whether EPCs result in increased uptake of energy efficiency measures is somewhat variable, with surveys suggesting between 8-17% of respondents reported acting on EPC recommendations (Consumer Focus, 2011), (DCLG, 2013).

Cost effectiveness: Not applicable.

Summary of EPCs	
Were SMART objectives set?	No – objectives to raise public awareness of energy use, to encourage uptake of energy efficiency improvements, and to comply with requirements of the EU Energy Performance of Buildings Directive.
Were the objectives met?	There is evidence of high awareness of EPCs, and moderate understanding of them, but lower uptake of the recommended energy efficiency measures.
Lessons learnt	There are a number of possible sources of error resulting in an EER not being reflective of the actual performance of the building.

A4.1.8 Display Energy Certificates (DECs)

Public buildings are obliged to display a DEC. DECs are required to be placed in a prominent place in buildings occupied by a public authority where the total useful floor area exceeds 250m^2, and which is frequently visited by the public. Public buildings in Scotland must have an EPC instead of a DEC.

Objective: To raise public awareness of energy use, to encourage uptake of energy efficiency improvements, and to comply with requirements of the EU Energy Performance of Buildings Directive.

Policy lever type: Standards and targets.

Tenure: Non-domestic buildings which provide a public sector service.

Measures: DEC is required to be displayed and is accompanied by a 'Recommendation Report' that contains possible improvements to the building.

Delivery mechanism: Responsibility to display a DEC lies with the occupier of a building. Validity of DECs depends on the total useful floor area: for buildings with more than 1,000m^2, the DEC is valid for 12 months; for between 250m^2 and 1000m^2, the validity is 10 years (DCLG, 2015). Some organisations undertake the DEC in-house whereas others contract out the process.

Funding pathway: Funded by building occupier.

Challenges: The DEC has been found to have a limited impact on energy use because of a lack of awareness and associated communication to staff and building users, benchmarking was often poorly understood, it reflects the building rather than the business therefore limited wider impetus to use it a as a mechanism for enhancing reputation.

Effectiveness: Research was undertaken in 2013 to understand the use of DECs and how they can encourage behaviour change (DECC, 2013). The research found that the DEC had limitations as a mechanism for promoting change, but that where an organisation was interested in energy, the DEC was a driver of change. Organisations reported that the Recommendation Report lacked detail and could be improved through more tailored guidance that takes into account budgetary constraints.

Cost effectiveness: Not applicable.

Summary of Display Energy Certificates	
Were SMART objectives set?	No – objectives to raise public awareness of energy use, to encourage uptake of energy efficiency improvements, and to comply with requirements of the EU Energy Performance of Buildings Directive.
Were the objectives met?	The DEC go some way to encourage building users to consider improvements to buildings.
Lessons learnt	It proposed that the Recommendation Reports could be improved by providing specific or tailored information on appropriate energy efficiency measures.

A4.2 Republic of Ireland

In the RoI, the Energy Efficiency and Affordability Division within DCCAE has responsibilities for drafting and implementing energy efficiency policy measures which will help Ireland reach its target, in accordance with the EU EED, to achieve a 20% reduction in energy demand across the economy by 2020, compared to projections made in 2007 for the year 2020.

The RoI has had in place the following strategies relating to energy efficiency:

- Warmer Homes: A Strategy for Affordable Energy in Ireland, 2011
- National Long Term Renovation Strategy, 2014
- Strategy to Combat Energy Poverty, 2016
- Public Sector Energy Efficiency Strategy, 2017
- The RoI Climate Action Plan, 2019, sets out how the country will meet its EU targets to reduce its carbon emissions by 30 per cent between 2021 and 2030 and lay the foundations for achieving net zero carbon emissions by 2050 (Dept. Communications, Climate Action & Environment, 2019).

The SEAI plays a leading role in transforming Ireland into a society based on sustainable energy structures, technologies and practices. The SEAI is responsible for delivering programmes and schemes relating to energy efficiency. Key energy efficiency policy levers in the RoI are provided in the table below, with further detail in the following sections.

Table 32: Energy efficiency policy levers in RoI

Policy lever	Applicable dates	Summary	Further detail
Better Energy Homes	2008 – present	A grant scheme to improve energy efficiency for qualifying owner occupiers and landlords.	A4.2.1
Deep Retrofit Pilot scheme	2017 – present	A pilot grant scheme to investigate the challenges and opportunities of deep retrofit across Ireland.	A4.2.2
Building Energy Rating	Present	An energy performance standard. A BER must be provided to prospective buyers or tenants when a home is offered for sale or rent.	A4.2.3
Warmth and Wellbeing Pilot	2016 – present	The scheme operates on referrals and aims to provide free, extensive energy efficiency upgrades to eligible homes, benefitting overall health and wellbeing.	-

Better Energy Communities	Present	Funding for community-based partnerships to improve energy efficiency of building stock in their area – homes, community facilities and buildings.	-
Building Regulations 2011	2011 – present	The 2011 domestic Building Regulations are one of a series of improved efficiency standards to help towards goal of Near Zero Energy Buildings by 2020.	-
Accelerated Capital Allowance	2008 – present	A tax incentive which aims to encourage companies to invest in technology which will save energy.	-
GreenStart	Ongoing	Enterprise Ireland scheme for SMEs. Up to 7 days of support (50% grant aided) to increase environmental awareness relating to regulatory compliance and to enable participants to develop a basic environmental management system.	-
GreenPlus	Ongoing	Enterprise Ireland 'Business Process Improvement Grant' of up to €70k to bring in external assistance to help review and revise company processes to secure and deliver resource and financial efficiencies.	-
Green Business Programme	Ongoing	Environmental Protection Agency's suite of projects aimed at helping enterprises save money and help to reduce their environmental impacts. Includes on-site resource efficiency assessments and an online resource efficiency self-assessment tool.	-
SEAI Larger Industry Energy Network (LIEN)	Ongoing	Companies are eligible if they are either spending at least €1 million on energy annually, or are certified to or pursuing ISO 50001 certification. SEAI works with these companies to improve their energy performance and on sharing good practice.	-
SEAI EXEED grant scheme	Ongoing	Grant support of up to €500,000 per year for energy investment projects. Funding up to 50% of the project.	-

A4.2.1 Better Energy Homes grant scheme

Better Energy Homes (originally Home Energy Savings Scheme) began in 2008 and is a grant scheme to incentivise residential energy efficiency retrofits, with different grant values based on nature of retrofit. Provides approximately one-third of the total cost of retrofit as a subsidy. Open to all homeowners and landowners and is not means tested.

Policy lever type: Funding (in the form of grants).

Objective: To support homeowners to retrofit their homes. Part of a suite of programmes to help Ireland reach a target of 20% improvement in energy efficiency by 2020. No SMART objectives for scheme on its own.

Tenure: Domestic: private landlords and privately-owned.

Measures: A range of measures offered. Includes attic insulation, draught-proofing, lagging jackets, low-energy lightbulbs, cavity wall insulation, energy advice, heating upgrades.

Delivery mechanism: The SEAI offers grants to homeowners who wish to undertake retrofit measures to improve the energy efficiency of their home. A household makes the first move, contacting an SEAI-registered contractor prior to applying for a grant who then installs the relevant retrofit measures once an application has been approved via the SEAI. A BER takes place after installation, not before which makes monitoring of effectiveness of works difficult. Some applications are made via intermediaries such as energy suppliers (Collins and Curtis, 2018).

Funding pathway: Funded by SEAI to the contractor following approval of grant process and subsequent works.

Challenges:

- Homeowners decide specific measures to adopt. The scheme focuses on specific inputs rather than outputs in energy savings which makes it difficult for applicants to understand what measure is best-suited for their needs (Mac Uidhir *et al.*, 2020).
- Participants need to self-finance approx. Two-thirds of the cost therefore tends to mostly be socio-economically advantaged (Collins and Curtis, 2018).
- Could be more effective if grant payment was proportionate to improvements in energy efficiency (Ibid.).

Effectiveness:

- 179,000 homes between 2009 and 2018 (Ibid.).
- A study on willingness-to-pay and free riding helped to determine cost-effectiveness of the scheme. It found that larger homes are less willing to pay on a per metre squared basis; households who have previously completed retrofit measures are more likely to pay; estimated 7% of participants would have occurred without the grant. Willingness-to-pay on average €0.127/kWh/year for retrofits affecting energy efficiency required for space and water heating.

Cost effectiveness: Information not available.

Summary of the Better Energy Homes grant scheme	
Were SMART objectives set?	Not for the scheme alone. Part of a range of measures to contribute to target of 20% improvement in energy efficiency by 2020.
Were the objectives met?	The scheme contributed to energy savings.
Lessons learnt	The scheme lacked guidance and information for applicants to assist in understanding appropriate measures for their homes. Relied on some self-finance therefore did not target economically disadvantaged. Grant payment was not proportionate to improvements in energy efficiency.

A4.2.2 Deep Retrofit Pilot Scheme

The scheme pilot was launched in 2017 with an aim to test the market readiness to deliver major home energy transformations (from both a supply and demand perspective). Grant support of up to 50% provided to homeowners, to support in upgrading energy performance to BER A. The scheme remains open after being extended to 2020.

Objective: To upgrade RoI's existing housing stock, through whole-house initiatives. The pilot ran to understand how deeper renovation could be achieved. No SMART objectives.

Policy lever type: Funding (in the form of grants)

Tenure: Domestic: private landlords and privately-owned.

Measures: Whole-house approach. Measures identified in terms of contributions to whole-house solution and included wall, attic and floor insulation, window and door upgrades, ventilation systems and wood-burning stoves.

Delivery mechanism: Overseen by the SEAI. Service providers delivered Deep Retrofit projects under the programme. Service providers submit a grant claim and are reimbursed for works undertaken.

Funding pathway: Funded by the SEAI.

Value for money: Average total capital cost to upgrade a home from an average BER rating of F to an average of A3 is £54,047 (SEAI, 2017b).

Challenges: Unanticipated interest in the pilot programme due to increased, positive dialogue across Ireland regarding climate change, which may have been the reason for the proposed pilot pause. Potential concern about value for money – following the pilot's 'pause' the SEAI noted the need to 'put in place new retrofitting delivery models which will group retrofit projects together to achieve economies of scale, to devolve this activity to a more local level, to leverage private finance and to ensure greater facilitation of investment as outlined in the All of Government Climate Action Plan'.

Effectiveness: 325 homes were completed in the Deep Retrofit pilot programme, all achieving a BER A rating. Most of these homes were detached / semi-detached. Total carbon savings from 325 homes was 12.44 GWh/year (SEAI, 2017b). Overall policy effectiveness is not clear; SEAI issued a suspension letter with a view to reviewing the pilot, but due to the impact on the existing pipeline of projects, it was reinstated until into 2020.

Cost effectiveness: Information not available.

Summary of Deep Retrofit Pilot Scheme	
Were SMART objectives set?	No – pilot undertaken to understand how deeper renovation could be achieved in Ireland's housing stock.
Were the objectives met?	Pilot received much higher than anticipated levels of interest.
Lessons learnt	Yet to be evaluated however the SEAI noted that improvements could be made including addressing economies of scale, working at a more local level and leveraging private finance.

A4.2.3 Building Energy Rating (BER)

The Irish BER is an energy label relating to the energy efficiency of a home and became mandatory in 2010. The BER is similar to the EPC used in the UK. EPCs show the energy performance on a scale from A to G, with A being the best performance and G the worst. The BER Certificate is more detailed in that it subdivides the A- G scale into A1, A2, A3, B1, B2, B3 etc.

Objective: To enable householders to understand the energy efficiency of their home (legally required to be included in all sale and rental advertisements).

Policy lever type: Standards and targets.

Tenure: All domestic properties. An owner must provide a BER to prospective buyers or tenants when a home is offered for sale or rent. New homes offered for sale off plans also require a BER. A provisional BER is issued based upon the design drawings and building specifications.

Measures: No specific associated measures.

Delivery mechanism: The SEAI is the issuing authority for the administration of the BER scheme. BER assessors are nationally recognised, independent assessors registered with the SEAI who undertake BER assessments and provide support to house buyers. They act as the main source of advice when carrying out energy efficiency improvements in the RoI and are therefore a key intermediary in energy efficiency delivery in homes due to their existing relationships with customers (SEAI, 2017a). A BER is valid for up to 10 years provided that there is no material change to the home that could affect the energy performance. A Provisional BER, derived from the plans for an as yet unbuilt home, has a maximum validity of 2 years.

Funding pathway: A building seller or landlord commissions a BER or it may be commissioned on their behalf by an agent such as an estate agent.

Challenges: Requires accompanied advice to present tailored options for individual households to meet their BER and provide a clear route directly to financiers and suppliers (SEAI, 2017a). BERs appear to be subject to similar challenges as EPCs described in section A4.1.7. A BER is only indicative of energy usage; it is based on the calculated energy performance and associated carbon dioxide emissions for the provision of space heating, ventilation, water heating and lighting, under standardised operating conditions. BERs use the Dwelling Energy Assessment Procedure (DEAP) calculation framework which draws heavily on the calculation procedures and tabulated data of the SAP for energy rating of dwellings in the UK (used for EPCs) (SEAI, 2020b). The characteristics of the major components of the home including dimensions, orientation, insulation, and space and hot water system efficiencies are used in the calculation. The actual energy usage will be dependent upon the behaviour of household members, which is not taken into account in the BER assessment (SEAI, 2014).

Effectiveness: The BER enables understanding of energy ratings and the level of retrofit required for a home. It has been found that consumers place high value on the BER with house buyers reviewing prior to purchase. The BER advisory report provides helpful retrofit advice and options. (Ibid.)

Cost effectiveness: Information not available.

Summary of the Irish Building Energy Rating (BER)	
Were SMART objectives set?	No – objective to enable householders to understand the energy efficiency of their homes.
Were the objectives met?	Yes – the rating enables understanding.
Lessons learnt	Requires accompanied advice to tailor options for improvement for households.

A4.3 Scotland

In 2015, the Scottish Government announced a commitment to treat the energy efficiency of the building stock as a national infrastructure priority. The aim is to deliver significant economic, social, environmental and health benefits, including the removal of poor energy efficiency as a contributory factor to fuel poverty. There is evidence that evidence suggests that Scotland designating energy efficiency as a national infrastructure priority has helped to improve its policy impact, making energy efficiency policy better designed and funded, longer-term, as well as more comprehensively governed and targeted, than in England (House of Commons and Business Energy and Industrial Strategy Committee, 2019).

Scotland's Climate Change Plan (Scottish Government, 2018a) sets out that by 2032, improvements to the building fabric of buildings will result in a 15% reduction in domestic heat demand and 20% reduction in non-domestic heat demand respectively.

The 'Energy Efficient Scotland' routemap (Scottish Government, 2018b) outlines steps that will be taken under the Energy Efficient Scotland programme to support homes, businesses and public buildings to become more energy efficient over the next 20 years. The routemap provides an overview of the measures due to put in place to improve the domestic and non-domestic building stock across Scotland, including minimum energy efficiency standards (see section A4.1.2).

There is likely to be a new Energy Efficiency Scotland routemap published by the end of 2020, alongside the new climate change plan and heat policy statement.

Stakeholder engagement revealed that Scottish Government is looking at developing a new loan and cashback scheme to promote heat decarbonisation in the non-domestic sector, on a larger scale than the Resource Efficient Scotland scheme. The aim is that when combined with other support, such as Renewable Heat Incentive (RHI), that all of intervention costs are covered within an acceptable timeframe. The scheme will likely be consulted on, but this is uncertain given the current coronavirus pandemic and the Scottish parliaments election in May 2021.

The table below provides a breakdown of a range of policy levers which have been implemented both prior to and following the implementation of the programme.

Table 33: Energy efficiency policy levers in Scotland

Policy lever	Applicable dates	Summary	Further detail
Home Energy Efficiency Programmes for Scotland (HEEPS): Warmer Homes Scotland	2013 - present	Provision of loans to homeowners and private sector tenants who meet qualifying criteria and are struggling to heat their home. Scheme is designed to help vulnerable people make their homes warmer and more comfortable.	A4.3.1
HEEPS: Area-based schemes	2013 - present	Funding provided to local authorities to develop and deliver energy efficiency programmes in areas with high levels of fuel poverty.	A4.3.2

Energy Efficient Scotland (EES) pilot projects	2016 – present	Pilots to inform the development of Energy Efficiency Scotland. Local authorities and partners were asked to develop proposals to deliver energy efficiency in domestic and non-domestic buildings. Also known as Local Heat and Energy Efficiency Strategies (LHEES) pilots.	A4.3.3
Energy Efficiency Standard for Social Housing (EESSH)	2014 - present	Minimum energy efficiency rating for social housing landlords to encourage investment in energy efficiency measures.	A4.3.4
Building Regulations	Ongoing	Minimum standards to which the erection, extension, or material alteration of buildings must adhere.	A4.1.1
HEEPS: Loans	2013 - present	Provision of five loan schemes including Home Energy Scotland Loans, Registered Social Landlords Loan, HEEPS Equity Loan, HEEPS Area Based Scheme Loan and HEEPS Warmer Homes Scotland Loan. Interest-free loans up to the value of £15,000 for energy efficiency measures, including a maximum cashback amount of £3,750. The 2017/18 budget was £30m. (Scottish Government, 2019c)	-
HEEPS: Advice and support service	2013 - present	Free and impartial advice and support service to all householders in Scotland to assist in finding the most appropriate scheme specific to their circumstances.	-
Resource Efficient Scotland	Ongoing	Funded by the Scottish Government, Zero Waste Scotland provide free, impartial support, including an energy opportunities assessment, to SMEs. Interest-free loans to businesses for the installation of energy efficiency measures and renewable technologies. These loans provide 15% cashback (previously set at 30%) on completion of the project (to a maximum value of £10,000). Grants are available for the implementation of measures that prevent waste.	-
Home Energy Scotland Loan Scheme	Ongoing	For homeowners: Interest-free loans for energy efficiency measures and renewable technologies through the Energy Saving Trust.	-
Private Rented Sector Landlord Loan	Ongoing	For landlords: Interest-free loans for energy efficiency measures and renewable technologies through the Energy Saving Trust.	-

A4.3.1 Home Energy Efficiency Programmes for Scotland (HEEPS): Warmer Homes Scotland

Objectives:

- Reduce fuel poverty by reducing heating costs to vulnerable households;
- Contribute to a reduction in the emissions of carbon dioxide from Scottish homes;
- Improve Scotland's housing stock;
- Offer good value for money by leveraging additional funding into the scheme; and
- Provide benefits to the wider community through vocational training and employment opportunities.

Policy lever type: Funding (interest-free loans).

Tenure: Domestic: privately-owned and private landlords.

Measures: Measures recommended for the property based on a survey of the property. May include solid and cavity wall insulation, loft insulation, draught-proofing, central heating, and renewables. Frequently takes a whole house approach.

Delivery mechanism: Scottish Government appointed Warmworks Scotland LLP to manage the contract on its behalf. Warmworks is a joint venture partnership between Energy Saving Trust, Changeworks and Everwarm and is responsible for all aspects of customer journey from initial survey through to after-care service (delivered by Warmworks on a regional basis). Scheme uses proxies to identify households most likely to be living in fuel poverty. Households are required to self-refer through Home Energy Scotland. If deemed eligible after an initial screening process, customers are referred to Warmworks, a home survey is booked. Warmworks then take over the management of the customer journey.

Funding pathway: Funded by Scottish Government. Worth at least £16 million per year for up to 7 years. 2016/17 cost was £24m and 2017/18 cost was £28m. In order to ensure value for money, Warmworks is leveraging additional funding into the scheme through: SSEN 'enabling funding', ECO, SGN connections, and Home Energy Scotland loans.

Challenges: Referrals were being made to Warmer Homes Scotland by applicants who did not qualify post-referral due to a high SAP or no suitable measures. Uptake by eligible customers could be increased – research shows that those receiving other allowances such as carer's allowance and disability benefits, pregnant women, and those under 30, have low uptake (Scottish Government, 2017).

Effectiveness: An annual policy review confirmed the scheme is on track to meet its objectives (Scottish Government, 2017). Over 16,000 households have received measures through the scheme, with the most common measures being new gas boilers and insulation (Scottish Government, 2019c). The majority of completed installations are owner-occupied, most likely due to other policy initiatives and Repairing Standard which places a duty on landlords in privately rented sector to ensure heating system is of reasonable quality (Scottish Government, 2019c).

Cost effectiveness: During 2016/17, total cost of £5,655 per household with an average of 2.8 measures per household (Scottish Government, 2019b).

Summary of the HEEPS: Warmer Homes Scotland

Were SMART objectives set?	No.
Were the objectives met?	Annual policy review confirmed the scheme was on track to meet its objectives in 2017.
Lessons learnt	Application system allowed referrals by applicants who did not qualify post-referral due to a high SAP/lack of suitable measures. Targeted approach to particular demographics would have improved uptake.

A4.3.2 Home Energy Efficiency Programmes for Scotland (HEEPS): Area-based schemes

The scheme began in 2013, comprising two parts: Core Allocation Programme providing councils with core funding based on a needs assessment, and the Proposals for Additional Funding enabling Scottish Government to provide additional funding to councils able to deliver more ambitious schemes (Citizens Advice Scotland, 2016).

Policy lever type: Funding (grants provided to local authorities).

Objectives:

- Reduce fuel poverty;
- Reduce carbon emissions;
- Lever ECO funding; and
- Support the local economy and sustainable local economic development.

Tenure: Domestic – restricted to privately-owned and private landlords.

Measures: A range of measures offered including solid wall insulation, loft and cavity measures, boiler replacement, etc.

Delivery mechanism: Schemes are administered by local authorities, although some local authorities sub-contract to third parties.

Funding pathway: All councils were provided with a core allocation of funding based on a needs-based assessment. Additional funds were provided to councils in a position to deliver larger scale and/or more ambitious projects. In 2016/17 the latter was removed with funding moved towards Scotland's Energy Efficiency Programme (SEEP) which became superseded by the 'Energy Efficient Scotland' routemap.

Challenges: Other schemes such as ECO are considered to have undermined delivery, for example uncertainty about level of ECO funding was a challenge for local authorities. Supply chain issues were reported. Some stakeholders questioned the capability of some local authorities to deliver the schemes, with a number sub-contracting to third-parties. No formal evaluation has been carried out (Citizens Advice Scotland, 2016).

Effectiveness: The way that the scheme was funded and delivered, on a local basis, has been found to ensure relatively equitable distribution of funding across Scotland whilst also targeting fuel poverty in some areas, and utilising local knowledge and trusted parties (Ibid.).

Cost effectiveness: Budget for 2016/17 was £40m. Budget for 2017/18 was £47m (Scottish Government, 2019c).

Summary of HEEPS: Area-based schemes	
Were SMART objectives set?	No.
Were the objectives met?	Considered to have been effective.
Lessons learnt	Considered to have been undermined by other schemes including ECO. Supply chain issues reported. Capability of local authorities to deliver was questioned.

A4.3.3 Energy Efficient Scotland (EES) pilots

Objectives: The pilots were undertaken to inform the overarching 'Energy Efficient Scotland' (EES) programme which has two overarching objectives, to:

- Remove poor energy efficiency as a driver for fuel poverty; and
- Reduce greenhouse gas emissions by 23% in the domestic and 59% in the nondomestic sectors by 2030 relative to 2015 levels, through improved energy efficiency and decarbonising the heat supply of buildings (Scottish Government, 2019a).

The EES pilots included Local Heat and Energy Efficiency Strategies (LHEES) that aim to link long-term targets and national policies to the delivery of energy efficiency and heat decarbonisation at local levels. They would allow local authorities to prioritise and target work through, for example, supporting owner-occupiers and businesses to install energy efficiency measures or encouraging the development of district heating and other low-carbon heat solutions.

Policy lever type: Grant funding.

Tenure: Domestic: private landlords and privately-owned. Non-domestic: private ownership and public buildings.

Measures: Phase 1 pilots domestic measures: external solid wall insulation; cavity extraction and refill; internal solid wall insulation; loft insulation; draught proofing; top-up loft insulation. Phase 1 pilots non-domestic measures: external solid wall insulation; connection to district heating network; installation of large-scale heat pump; Underfloor heating, loft insulation; building energy management systems; LED lighting; draught proofing; biomass network extension; installation of a biomass boiler; replacement windows; heat exchanger maintenance, thermostatic radiator valves; flat roof insulation.

Delivery mechanism: Local authorities and partners were asked to develop and submit proposals to deliver energy efficiency in domestic and non-domestic buildings.

Scottish Government has funded two phases EES pilot projects, with a third currently ongoing:

- Phase 1 pilots were carried out between September 2016 and Spring 2018. This included projects across nine local authorities to help them develop heat and energy efficiency strategies.
- Phase 2 pilots commenced in September 2017 for a further ten local authorities. Alongside domestic and non-domestic building retrofits, Phase 2 incorporated the piloting of LHEES which require councils to develop area-based heat and energy efficiency and heat decarbonisation plans for a specific area over a 15-20 year period.
- Phase 3 pilots. The remaining 9 local authorities will be given a budget of £50,000 each for delivery of a pilot project, for completion by December 2020. The aim is for the phase 3 pilot projects to test the six-stage process as outlined below:
    - Stage 1: An assessment of existing local and national strategies and data availability.
    - Stage 2: Area-wide assessment of existing building stock's (domestic and non-domestic) energy performance and heat supply.
    - Stage 3: Area-wide setting of aggregate targets for heat demand reduction and decarbonisation of all buildings – for the short-term strategy period and for the long-term duration of Energy Efficient Scotland.
    - Stage 4: Conduct a socio-economic assessment of potential energy efficiency and heat decarbonisation solutions.
    - Stage 5: Selection of areas/prioritisation of opportunities for energy efficiency and/or heat decarbonisation, leading to the designation of zones.
    - Stage 6: Costing & phasing of delivery programmes.

Funding pathway: Total of £9m allocated from two existing Scottish Government funding streams: HEEPS and Low Carbon Infrastructure Transition Programme (LCITP). Local authorities are also encouraged to find match funding to supplement where possible. Funding included:

- Grant funding for non-domestic elements of the pilot from the LCITP
- Remedial/maintenance work was not included
- Commercial organisations not eligible for grant funding

Challenges: Following the first phase of pilots, some recommendations were made for the non-domestic approach (Bush *et al.*, 2018):

- Planning for whole building and area-based retrofit needs accurate data on building stock, standards and retrofit options. There would be benefit in each local authority developing an electronic standard system, accessible across different departments, estates and services, although this would have significant financial implications.
- Short-term funding restricts activities to certain project-types, potentially leaving the more expensive works for the future. Long-term complex programmes for energy saving retrofit of buildings would benefit from multi-year funding plans.

- Managing the coordination of area-based retrofit, even on a small scale, requires significant local authority staff time and new cross-council teams;
- It is important to evaluate the success of pilots of this nature. However, data collection requirements for both the technical and social aspects of the evaluation, as well as financial investment in technical monitoring equipment, was challenging for councils.
- Councils use varied approaches to project delivery. Some used in-house resources for project planning and delivery; others appointed external contractors to carry out these tasks. Further work is needed to compare costs and benefits of in-house management and outsourcing.
- Development of comprehensive LHEES needs to combine distinctively local elements, to address specific contexts, with opportunities to pool energy planning expertise across Scotland, for access by all local authorities. Standardised 'best practice' methodologies are needed to support consistency in planning across the country, and to manage uncertainty in data and methodologies.
- Local authorities highlighted the need for extensive, coordinated public engagement to establish understanding and acceptance of low carbon heating technologies and energy efficiency measures. This engagement must extend across the commercial, industrial, third, and public sectors.

Effectiveness: The pilot projects were successful in providing understanding and information of local authority and delivery partner expertise and good practice along with lessons learnt for addressing both domestic and non-domestic sector (Bush *et al.*, 2018). The pilot projects delivered energy efficiency and low carbon heat measures in 1,456 domestic buildings and 47 non-domestic buildings (Ibid.).

Cost Effectiveness: Information not available specifically for the pilots. However, the potential economic impacts of the wider Energy Efficient Scotland Programme have been researched. Turner, et al. (2018) estimated that the combination of enabling energy efficiency gains and the knock-on impacts of realising this gain on household spending power, will deliver a cumulative boost of £7.8 billion in real-terms GDP to Scotland over the next 30 years. The GDP boost also equates to the sustained delivery of an additional 0.2% in Scottish GDP into the long term. The GDP boost would be associated with around 6,000 sustained (full-time equivalent) jobs, realised in the fourth year of the programme and largely sustained in the long term.

Summary of Energy Efficient Scotland Phase 1 Pilots	
Were SMART objectives set?	No – undertaken to inform overarching programme.
Were the objectives met?	Yes – succeeded in informing overarching programme.
Lessons learnt	Significant local authority staff time requirements; data collection is challenging; further work is needed to compare approaches to project delivery; best practice methodologies are needed to support consistency; and extensive, coordinated public engagement is required. Non-domestic social survey data showed that building occupants attributed value to the works over and above

	carbon emission reductions and energy savings. In particular, visible improvements were valued highly: e.g. LED lighting improved the atmosphere of a space, and external wall insulation improved the aesthetics of the buildings. When considering scaling up to more complex and innovative energy efficiency programmes, essential local authority staff resources and skills were perceived as lacking. Expertise to engage with non-domestic organisations beyond the public sector is one particular gap. Another is the expertise to work with households who will need to borrow or use savings to upgrade property. This extended cross-sector intermediary role for local authorities on energy use in buildings is unprecedented and will require new types of organisation, networks and procedures.

A4.3.4 Energy Efficiency Standard for Social Housing (EESSH)

The EESSH was introduced in 2014 to encourage social landlords to improve the energy efficiency of their housing stock.

Policy lever type: Standards and targets.

Objectives: Depending on fuel and dwelling type, it sets a minimum energy efficiency rating of SAP 2009 between 60-69 (equating to EPC D or C) to be achieved by 2020.

Tenure: Domestic: social housing.

Measures: To reach targets, information provided about available funding sources for social housing landlords to install energy efficiency measures.

Delivery mechanism: Scottish Government compiled information for landlords which identified funding sources for energy efficiency measures and wider information. The funding sources available included the Transition Programme for Energy Efficient Scotland which was a £3.5m decarbonisation fund for energy efficiency measures within projects. Social landlords required to provide the Scottish Housing Regulator with annual compliance information. Engagement with social tenants and landlords was undertaken to improve uptake.

Funding pathway: A number of funding sources are available including the ECO, etc. however a study found that most of the funding for meeting the EESSH comes from landlords' own resources (Scottish Government, 2019c).

Challenges: The levels of investment required to meet the standard was a challenge, in particular for specific properties.

Effectiveness: In 2019, the Scottish Housing Regulator reported that 85% of social housing was already meeting the 2020 milestone (Scottish Government, 2019c).

Summary of Energy Efficiency Standard for Social Housing (EESSH)

Were SMART objectives set?	No.
Were the objectives met?	Considered to be effective at encouraging uptake of energy efficiency improvements.
Lessons learnt	Self-finance of measures was a key challenge.

A4.4 Wales

The Welsh Government has made a commitment to become carbon neutral by 2050. However, 80% of the housing stock of 2050 has already been built. To hit the 2050 targets, Wales is expected to retrofit 40,000 homes a year until 2050, reducing the energy demand by a factor of three (National Assembly for Wales, 2018).

The Welsh Government ‘s Energy Efficiency Strategy (2016 - 2026) sets out the approach to improving energy efficiency in Wales. The Strategy sets out five key areas of action to deliver the vision for Wales to realise its full energy efficiency potential whilst becoming a major exporter of energy efficiency technology and knowledge. The key areas of action are overcoming barriers, developing the supply chain, skills and education, innovation and finance.

The Welsh Government’s Warm Homes Programme is the main instrument to deliver energy-efficient measures in the housing stock. It includes the Nest and Arbed schemes, which are described in the table below.

Research was undertaken by Cardiff University in 2019 (Green *et al.*, 2019) to understand the degree to which the existing Welsh housing stock could and should inform the development of a pathway to decarbonisation. The research finds that key metrics such as dwelling type and house characteristics influence retrofit strategy adopted and its effectiveness, and makes recommendations for the housing sector to contribute towards the 2050 decarbonisation target.

Table 34: Energy efficiency policy levers in Wales

Policy lever	Applicable dates	Summary	Further detail
Warm Homes Nest scheme	2011 - present	Means-tested, demand-led funding and advice scheme for energy efficiency improvements in homes.	A4.4.1
Warm Homes Arbed scheme	2009 - present	Demand-led funding and advice scheme for energy efficiency improvements in homes. Area-based scheme.	A4.4.2
Building Regulations	Ongoing	Minimum standards to which the erection, extension, or material alteration of buildings must adhere.	A4.1.1
Minimum Energy Efficiency Standard (MEES)	2018 – present	Set a minimum energy efficiency level for domestic private rented properties and non-domestic private rented properties.	A4.1.2
Energy Efficiency Loan Fund	Ongoing	Administered by the Carbon Trust. Provides interest-free loans of between £3,000 and £200,000 for energy efficiency and renewable energy projects to SMEs in Wales. This Fund has helped over 700 businesses in Wales save over £9 million per year on their fuel costs.	-

A4.4.1 Warm Homes Nest scheme

The Nest scheme was introduced in 2011, replacing the former Home Energy Efficiency Scheme (HEES). Nest is a means-tested demand-led scheme that offers funding and advice for energy efficiency improvements in homes, mostly related to central heating installations but also to standard insulation. Provides free home energy efficiency improvements for people in receipt of a means tested benefit that own or privately rent a home in the least efficient bands E, F, G.

Policy lever type: Technical advice and funded energy efficiency implementation.

Objectives: Reduce fuel poverty in Wales by improving building energy efficiency.

Tenure: Domestic properties with low-income owners or located in the most disadvantaged areas of Wales. The properties included 73.7% owner occupied and 26.3% privately rented properties (values for 2018-19) (Nest, 2019).

Measures: Advice on saving energy, money management, energy tariffs, and benefit entitlement. In addition to free advice, owner-occupied and privately rented properties might be eligible for home improvements (such as central heating installation or increased insulation) at no cost.

Delivery mechanism: The Nest scheme is managed on behalf of the Welsh Government by British Gas, working together with the Energy Saving Trust.

Funding pathway: The total expenditure for the Nest scheme was £158.7m, comprising £143.2m from the Welsh Government and £15.5m from ECO and its predecessor schemes (Auditor General for Wales, 2019).

Challenges: May not be reaching all in need and general challenges arise in targeting fuel poor households. A 2015 Welsh Government evaluation (Welsh Government, 2015) of Nest found that around 22% of beneficiaries it surveyed were not actually in fuel poverty. Some fuel poor households are not eligible for support from Nest. Difficulty to measure scheme's impact on fuel poverty (difficulty to collect accurate information, changes in households, changes in energy prices, rebound effect[24], and monitoring can be costly and intrusive).

Effectiveness: Since inception to March 2019, the Nest scheme provided advice to 129,500 households. The 2015 evaluation found 59% of those surveyed acted on it. Energy bills savings have been of £409/year on average. Over 37,000 households received free energy improvements since the programme's inception in 2011. Prior to receiving energy efficiency improvements, 43.3% of households were in fuel poverty (including 9.5% in severe fuel poverty). After the installation of home efficiency measures, the percentage dropped to 21% (including 3% in severe fuel poverty). Behaviour changes were reported, such as reducing the heating setpoint and the operative hours of the heating system and switching off appliances/lights when not in use.

Cost effectiveness: In 2017/18 £19.5m was invested in the scheme.

Summary of Warm Homes Nest scheme	
Were SMART objectives set?	No – objective to reduce fuel poverty in Wales through improving building energy efficiency.
Were the objectives met?	Considered to be effective in contributing to reduced fuel poverty.
Lessons learnt	A challenge to target fuel poor households and monitor impacts of scheme on fuel poverty.

A4.4.2 Warm Homes Arbed scheme

The Warm Homes Arbed scheme is equivalent to the Nest scheme, but it is an area-based scheme as opposed to a demand-led scheme. It was introduced by the Welsh Government in 2009.

Policy lever type: Technical advice and funded energy efficiency implementation.

Objectives: Help eradicate fuel poverty.

[24] The rebound effect is the erosion of potential energy saving by a behavioural response. This is particularly relevant for fuel poor households as, pre-retrofit, homeowners may not have been able to afford to heat their home sufficiently. Therefore, the carbon saving benefits which may have been assumed through the delivery of retrofit measures are eroded as the home is more adequately heated for the first time (Aydin, et al., 2017).

Tenure: Domestic properties. 90% owner-occupied, 10% private rented. 93.05% houses, 4.17% bungalow, 2.78% flat.

Measures: Included boiler upgrades and replacements, window upgrades, roof extensions and structural work, solid wall insulation, photo-voltaic panels, solar heated hot water.

Delivery mechanism: The Welsh Government delivered two phases of the Arbed funding (Phase 1 2009/12 and Phase 2 2012/15). Between Phases 2 and 3 (2016/18) the Welsh Government ran its Arbed Local Authority Partnership scheme, which offered local authorities grant funding to carry out improvements to properties. Phase 3 is ongoing (2018/21).

Funding pathway: The total expenditure for the Arbed scheme was £162.9m, comprising £108.6m from the Welsh Government (including £33m EU Structural Funds) and £54.3m from ECO and its predecessor schemes (Auditor General for Wales, 2019).

Challenges: Incorrect installation, difficulty in sourcing good quality workmanship, issues with detailing that had to be dealt with on-site causing delays. Dealing with too many properties simultaneously. Struggled to spend its allocated budget. Difficulty in targeting fuel poor households (many fuel poor households may not be in areas covered by Arbed). Difficulty to measure scheme's impact on fuel poverty (difficulty to collect accurate information, changes in households, changes in energy prices, rebound effect[24], monitoring can be costly and intrusive).

Effectiveness: Over 17,000 properties benefitted from this scheme since inception to 2019. A clear improvement of EPC values across the properties was visible.

Cost effectiveness: Arbed 3 will invest £54m over the lifetime of the project, which will run from 2018–21.

Summary of Warm Homes Arbed scheme	
Were SMART objectives set?	No – objective to help eradicate fuel poverty.
Were the objectives met?	Considered to be effective in contributing to reduced fuel poverty.
Lessons learnt	Problems with quality of works undertaken. A challenge to target fuel poor households and monitor impacts of scheme on fuel poverty.

A4.5 Germany

'Energy Efficiency Strategy for Buildings' (Federal Ministry for Economic Affairs and Energy (BMWi), 2015) sets out the approach Germany is taking to reach its goal of achieving a virtually climate-neutral building stock by 2050. The table below provides an overview of policy levers in Germany.

Table 35: Energy efficiency policy levers in Germany

Policy lever	Applicable dates	Summary	Further detail
Energy Efficiency Networks Initiative	2014 - present	Energy-efficiency networks alliance set up with an aim to set up approximately 500 new networks by 2020 (each consisting of 8-15 companies) which sets an efficiency target which companies use to develop plans and invest in energy efficiency based on clear data.	A4.5.1
CO_2 Building Rehabilitation Programme	2001 - 2009	loan and grant programme for building refurbishment.	A4.5.2
Special fund for energy efficiency in SMEs	2008 – present	A fund offering partial subsidies for energy audits to identify potential energy savings in SMEs.	A4.5.3
Minimum Standards for New and Refurbished Buildings (EnEV 2009)	2009 – present	Minimum standard for all new and refurbished buildings.	A4.5.4
PassivHaus standard	Launched in 1988	Voluntary standard for energy efficiency in a building, which goes further than regulations for minimum standard (EnEV 2009)	-
Energy Efficiency Fund	2011 - present	Part of the 'Energiewende'. Comprises 23 policy measures	-
Energy Efficiency Incentive programme	2016 – present	Programme to supplement existing funding programmes including CO_2 Building Modernisation Programme and Market Incentive Programme.	-

Policy lever	Applicable dates	Summary	Further detail
Energy consulting in SMEs	2013 - present	Programme to advance amount of energy consultations carried out in SMEs and enhance energy saving potential. Provision of advisory support and investment support.	-
Green Mortgages	Ongoing	To encourage investments in energy efficiency, Commerzbank offers discounted financing conditions for the construction or purchase of low-energy properties. Buildings with final energy consumption of less than 75 kWh per square meter of usable area are eligible.	

A4.5.1 Energy Efficiency Networks Initiative

The Federal Ministry for Economic Affairs and Energy and the Federal Ministry for Environment introduced the Energy Efficiency Networks Initiative in Germany in 2014 as a voluntary agreement scheme for the development of energy efficiency networks whereby energy managers of different organisations meet regularly to share experiences and discuss solutions.

Policy lever type: Voluntary scheme.

Objectives: Target of 500 networks.

Tenure: Energy performance of organisations.

Delivery mechanism: Overseen by the German Energy Agency. To register, an energy efficiency network must have already been running for 2 years, have at least 5 participating companies, be supported by qualified moderators and energy consultants, define a common energy saving target and participate in the monitoring process.

Funding pathway: Not publicly funded. Administrative costs are financed by network participants and funding programmes are available in some regions. Network participation costs vary between 1000 and 5000 Euros per year.

Challenges: Networks tend to adjust to the needs of the participants which results in a trade-off between reducing barriers to participate thereby resulting in more energy savings, and provision of control about the governance of the network initiative (Voswinkel et al. 2018).

Effectiveness: Considered to be a success to date, with 160 established networks in 2018 which equates to 1000 companies in total (Voswinkel et al. 2018).

Summary of Energy Efficiency Networks Initiative	
Were SMART objectives set?	No – aimed to create 500 networks.
Were the objectives met?	Considered to be a success to date, with 160 established networks in 2018.
Lessons learnt	As the networks are led by industry, targets can be adjusted to suit their needs and don't necessarily encourage major investment/improvements.

A4.5.2 CO_2-Building Rehabilitation Programme

The CO_2-Building Rehabilitation Programme (CBRP) is a low interest loan and grant programme for building refurbishment. The scheme ran from 2001 to 2009 when it was replaced by two separate programmes.

Policy lever type: Funding (loans and grants).

Objectives: To reduce carbon emissions from existing housing stock.

Tenure: Domestic: private landlords and privately-owned.

Measures: A choice of pre-defined packages were offered which included insulation, window and boiler replacement, heating upgrades.

Delivery mechanism: Administered by the KfW bank. The Federal Government sets the framework and KfW undertakes the delivery of loans and grants for energy efficiency measures.

Funding pathway: The federal government funds the CBRP, enabling KfW to issue loans with low interest rates (below market rates).

Challenges: The policy lever was heavily influenced at times by politics and vice versa. The funding mechanism requires a dependency on annual budgets which placed a strain on the programme, with unpredictability of funding affecting the market uptake. Similarly, during the recession, ministers used the CBRP to stimulate economic activity which led to higher public debt and this was later used by a different minister to cut the budget (Rosenow *et al.*, 2013).

Effectiveness: Considered to be a highly effective policy lever. Between 2006 and 2009, one million existing homes were retrofitted, creating almost 900,000 jobs in the building and building supply industries (Power and Zulauf, 2011).

Cost effectiveness: Between 2006 and 2010, CBRP saved on average 19 $mtCO_2$ per year (not including rebound or free rider effects) (Rosenow *et al.*, 2013).

Summary of the CO_2-Building Rehabilitation Programme	
Were SMART objectives set?	No – objective to reduce carbon emissions in housing stock.

Were the objectives met?	Considered to be effective.
Lessons learnt	Low interest rates encourage uptake by consumers.

A4.5.3 KfW special fund for energy efficiency in SMEs

A fund offering partial subsidies for energy audits to identify potential energy savings in SMEs. An internal audit of up to two days is subsidised by 80% of the audit costs. The fund began in 2008 and is remains in operation.

Policy lever type: Funding (in the form of a grant for energy advice).

Objectives: To promote energy efficiency in small and medium enterprises (SMEs).

Tenure: Non-domestic properties.

Measures: Audits undertaken by independent, qualified consultants.

Delivery mechanism: Managed by KfW bank, which is responsible for approving applications and paying out grants as well as checking consultant qualifications. Direct communication with companies delegated to regional partners (Gruber *et al.*, 2011). Partial studies offered for energy audits to identify energy saving potentials in SMEs by qualified and independent consultants, overcoming know-how deficits and obstacles where subsidies should encourage SMEs to make use of audits (Schlomann and Eichhammer, 2012).

Funding pathway: Government funded, through the KfW bank.

Challenges: Broader campaigns have not proven to be sufficient for outreach activities, but it's expected that personal communication between intermediaries and SMEs will result in an increased take-up over the next few years (Gruber *et al.*, 2011).

Effectiveness: Considered to be an effective policy lever for promoting energy efficiency in SMEs. Measures implemented resulted in 1.4TWh energy savings per year (Ibid.).

Cost effectiveness: Cost of 0.5-0.7 Euro/MWh energy saved (Schlomann and Eichhammer, 2012).

Summary of the Special fund for energy efficiency in SMEs	
Were SMART objectives set?	No – objective to promote energy efficiency in SMEs.
Were the objectives met?	Considered to be effective.
Lessons learnt	Communication strategy was based upon a broader campaign. Use of intermediaries to target SMEs directly anticipated to encourage uptake.

A4.5.4 Minimum Standards for New and Refurbished Buildings (EnEV 2009)

Revised building requirements which set targets for energy performance and a minimum standard for all new buildings.

Energy Saving Ordinance (EnEV) is a performance-based code which aims to ensure that the governments targets are achieved for reduction in use of primary energy for residential and non-residential buildings. Many buildings across Germany have applied the voluntary energy efficiency standard Passivhaus, which has more stringent energy efficiency standards. It aims to provide high level comfort and air quality while using very limited energy (less than 15kWh/m^2/yr for space heating and cooling demand).

Policy lever type: Standards and targets.

Objective: All new buildings must meet a legal standard of energy performance. Existing buildings must also achieve the maximum performance possible for the part of the building being renovated, with some leeway compared to new buildings.

Tenure: Domestic and non-domestic.

Measures: Statutory requirement for building performance.

Delivery mechanism: Delivered through regulation, enforced by the Federal Government.

Funding pathway: Government funded.

Challenges: Issues with enforcement. No auditing is carried out, which means that contractors and homeowners do not expect any infringement to be pursued or penalised (Weiss, Dunkelberg and Vogelpohl, 2012).

Effectiveness: Considered to be effective, but it does have challenges. Enforcement could be strengthened along with better utilisation of appropriate times to refurbish i.e. identify periods of opportunity such as transfer of home ownership (Ibid.).

Cost effectiveness: Information not available.

Summary of Minimum Standards for New and Refurbished Buildings (EnEV 2009)	
Were SMART objectives set?	No – all new buildings must meet legal energy performance standard.
Were the objectives met?	Considered to be effective.
Lessons learnt	No performance monitoring or auditing carried out.

A4.6 The Netherlands

The energy-efficiency strategy for the Netherlands is based on the Energy Agreement, in which energy savings in the built environment play an important role. The following objectives were reconfirmed by the signing parties:

- The objectives from European EED, the Energy Performance of Buildings Directive (EPBD), and the Ecodesign Directive;
- Existing buildings: move 300,000 per year existing residential buildings and other buildings up two label stages;
- New buildings: Nearly zero-energy buildings (NZEB) from 2020 (and from 2018 for government buildings) in accordance with EPBD directive;
- Rental: average label B in the social rental sector and a minimum label C for 80% of private rental properties.

An updated version of the Energy Agreement is the Climate agreement (or Klimaatakkoord), which was presented in 2019 and is discussed below. The government facilitates and encourages third parties to take energy-saving measures and deals with restrictive regulations. The strategy comprises three focus areas (Beckman and van den Beukel, 2019): i) informing and raising awareness; ii) facilitating (such as the Stroomversnelling discussed below); and iii) financial incentives (such as STEP, ISDE and EIA discussed below). Both residential and non-residential buildings are considered.

A 2015 legal case calling on the Dutch government to go further in its carbon emission reductions than required by EU law, was upheld on appeal in 2018 & 2019 (BBC, 2019) (Government of the Netherlands, n.d.). Earth tremors between 2013 and 2018 caused by drilling for gas (Meijer, 2019) have led the Dutch government to commit to an end to onshore gas production by 2030.

In June 2019 the Dutch government published their Climate Agreement with details of how carbon emission reductions will be delivered. This agreement includes details of how reliance on gas for domestic heating will be reduced, district by district, working together with municipalities (Government of the Netherlands, 2019) (Ende, 2017).

Table 36: Energy efficiency policy levers in the Netherlands

Policy lever	Applicable dates	Summary	Further detail
Climate agreement (Klimaatakkoord)	2019 - present	Climate agreement includes set of measures to combat climate change including specific information about the built environment.	A4.6.1

Policy lever	Applicable dates	Summary	Further detail
Energiesprong/Stroomversnelling	Stroomversnelling brokered in 2013 Market initiative in 2015	Original Energiesprong network aimed to create net zero energy (NZE) buildings on a large scale. The 'Stroomversnelling' deal was brokered in 2013 to refurbish 111,000 homes. In 2015, this evolved into a market initiative for NZE.	A4.6.2
Energy-saving at Home subsidy scheme (SEEH)	2016 - present	Subsidy covering 20% of expenses relating to carrying out two or more insulation measures.	A4.6.3
The Sustainable Energy Investment Grant (ISDE)	2016 - present	Subsidy scheme for homeowners and small businesses to purchase heat pumps, biomass boilers, solar water heaters, pellet stoves and small wood fired boilers.	A4.6.4
Incentive scheme for energy performance in the rental sector (STEP)	2014 – 2018	Financial incentives for the rental sector. Directly linked to Energy Agreement which requires all social rental sector properties to have minimum standard EPCs.	A4.6.5
Energy Investment Allowance (EIA) for landlords	2018 - present	Government tax scheme which provides support for investments in energy saving equipment and sustainable energy by businesses.	A4.6.6
Subsidy scheme for energy savings in social housing of Amsterdam	2011 – 2014	Subsidies to housing corporations for progression along each label step.	-
Long-Term Agreements on Energy Efficiency for the non-ETS sector and ETS sector.	2001 – present	Agreements by organisations to long-term energy efficiency plans.	-

A4.6.1 Climate agreement

On 28 June 2019, the Dutch government presented the new climate agreement (*Klimaatakkoord*) (Dutch Government, 2019). It contains a set of measures drawn up in consultation with various parties across Dutch society in the joint combat against climate change. The climate agreement contains specific information about the built environment.

Policy lever type: Standards and targets.

Objectives: Ensure reduction of 3.4 Mt of CO_2 in the built environment by 2030, compared to the reference scenario through making homes more sustainable. Cut non-residential building emissions by an additional 1 $MtCO_2$ by 2030. Retrofit 50,000 existing homes/year by 2021 and 200,000 homes/year by 2030, for a total sustainable transformation of 7m homes and 1m buildings by 2050. Switch all buildings (7.7m houses and 1m other buildings) from natural gas to district heating and electric heat pumps by 2050, with possibly minor supplementary roles for 'renewable gas' and hydrogen. As an intermediate target, 1.5m houses are to be made 'sustainable' by 2030.

Tenure: Residential tenures, and non-residential buildings.

Measures: Incentivisation and management via the district-oriented approach and the starter motor. Agreements on the development of arrangements and standards (in kWh/m^2/year). Mix of pricing and subsidy instruments (see for example ISDE and Energy Investment Allowance for landlords).

Delivery mechanism: Multiple stakeholders for each initiative comprised in the climate agreement.

Funding pathway: Government-funded.

Challenges: 'This endeavour is not a technical, financial or administrative challenge, but a social challenge. It's about people.' (Dutch Government, 2019). High costs of disconnecting existing houses from the gas grid (Van Hoek, T. & Koning, 2018) due to too ambitious and complex target. Uncertainty about the feasibility of achieving targets. Municipal or regional heating plan is more efficient than a neighbourhood-by-neighbourhood approach (for example, heating networks only become efficient when applied to > 3,000 housing units (Verhaegh, 2018).

Effectiveness: Policy in progress.

Cost effectiveness: Information not available.

Summary of the Climate agreement	
Were SMART objectives set?	Yes – reduction of 3.4 Mt of CO_2 in the built environment by 2030.
Were the objectives met?	Policy is underway.
Lessons learnt	Considered that municipal or regional heating plan is more efficient than a neighbourhood-by-neighbourhood approach

A4.6.2 Energiesprong/Stroomversnelling

In the Netherlands, the Energiesprong network is known as 'Stroomversnelling' ('Rapid acceleration'). This association originated from an earlier government funded Dutch innovation programme called Energiesprong ('energy leap'), which aimed to create Net Zero Energy (NZE) buildings on a large scale. In 2013, Energiesprong brokered the "Stroomversnelling" deal between Dutch building contractors and housing associations to

refurbish 111,000 homes to NZE (also called 'zero-on-the-meter' in the Netherlands). Two years later, Stroomversnelling evolved into a market initiative designed to take NZE to the next level. In other countries the name Energiesprong is still in use.

Policy lever type: Funding (loans and grants), technical services and assistance.

Objectives: Reach zero energy for the whole building stock. This initiative aims to reduce the renovation costs of NZE refurbishments, increase occupants' acceptance of these renovations and increase the pace of growth in the NZE housing market itself.

Tenure: Residential tenures.

Measures: Whole house refurbishment and new build standard and funding approach. The contractor offers a 30-year energy performance guarantee for net-zero annual energy consumption amortised over the calendar year. Offsite manufacture and modularisation are used to limit the duration of the retrofit under one week.

Delivery mechanism: Housing associations provide the upfront capital to pay the building companies that provide the retrofits, and then recoup the cost through savings to their tenants; energy bills at no net additional cost to tenants.

Funding pathway: Initially Dutch Government funded. The scheme began as a government-funded innovation programme to drive an improved energy efficient standard in the Dutch market. Today, the scheme is based on future energy cost savings and budget savings for planned maintenance and repairs over the next 30 years. When a building is retrofitted with the scheme to NZEB, the costs of the retrofit are paid by the occupants back to the housing association as a service fee (increased rent). These additional payments are equal to or smaller than the energy bills currently paid by the occupants (which the occupants don't need to pay anymore as the building became net-zero). The payments are to be made over a 30-year lifespan and take into account an interest from a bank loan. The houses would still have a contract with a utilities provider so if the energy use is exceeded by the tenant, money is paid to the utilities company as usual. There is a risk that tenants will use retrofitted properties inefficiently, driving up energy costs. While the scheme implies that such costs would fall on the tenant, it is still crucial for the success of the scheme that retrofits are perceived as performing well for tenants.

The initial funding was 50m Euros Government funding (2010/16), six billion Euros WSW Social Bank funding for Stroomversnelling deal, additional European project funding (3.6m Euros from Transition Zero H2020, 5.4m Euros from E=0 Interregional NW Europe).

Challenges: Laws and regulations had to be amended to encourage projects with high saving goals.

Effectiveness: Over 5,000 homes have been retrofitted at no cost for the residents; Energiesprong has successfully delivered NZE retrofits to over 2,000 new and existing homes so far and has agreed to retrofit 111,000 Dutch homes by 2020. The success of the Energiesprong business model has led to it being exported to international markets. The UK and France, for example, aim to apply this business model and retrofit about 100,000 home in each country over the next years.

Cost effectiveness: Cost-effective measure. A number of countries are following the Dutch example due to the attractive business model.

Summary of Energiesprong/Stroomversnelling	
Were SMART objectives set?	No – aim to reach zero energy for the whole building stock.
Were the objectives met?	Considered to be an effective model, however zero energy target has yet to be met.
Lessons learnt	Considered to be an attractive model which other countries are replicating.

A4.6.3 Energy-saving at Home subsidy scheme (SEEH)

The SEEH (*Subsidie energiebesparing eigen huis)* covers 20% of the expenses faced when carrying out two or more insulation measures (such as insulating roof, walls, floor or windows), for a maximum of 10,000 Euros per property. If the property is made very energy efficient or energy neutral, a bonus subsidy is available.

Policy lever type: Funding (loans and grants).

Objectives: Encourage homeowners to carry out energy-efficiency measures in their properties.

Tenure: Residential buildings. Only available to homeowners who live in their property. Only existing properties.

Measures: The subsidy, which comprises approximately 20% of the investment, will only be issued when at least two of the following energy saving measures are performed, under the conditions set out in the subsidy scheme: wall insulation, cavity wall insulation, roof insulation, floor or ground insulation and replacing windows with low-emissivity glass.

When at least two energy saving measures are implemented under this requirement, the owner-occupier or owners' association can also receive an additional subsidy for further energy saving measures, such as insulating doors or customised recommendations.

The measures and associated requirements largely correspond to the measures and requirements for the National Energy-saving Fund (National Energiebespaarfonds (NEF)) This means that the subsidy and loan can be combined to cover the entire investment (International Energy Agency, 2019).

Delivery mechanism: Owner-occupants and owners' associations that implement an extremely energy efficient package of measures receive a bonus over and above the subsidy of €4,000 per home. As a rule, such a package is considered to be renovating a home, for example, so that it becomes zero-energy. National scheme, working in tandem with the ISDE subsidy.

Funding pathway: Over €84m made available by the Dutch Government as a subsidy. Aside from this subsidy, €4.5 million is available in subsidies specifically for owners' associations for energy recommendations, a long-term maintenance plan involving energy saving measures (green LTMP) and process guidance. The intention of this subsidy is to provide guidance to owners' associations in the transition to energy saving measures.

Challenges: Limited control groups.

Effectiveness: To be determined (ends 31 December 2022). The measure is generally considered a success, with applications surpassing expectations (more than 13,000 applications were received in 6 months) and the cap for the subsidy has been continuously increased during the last years.

Cost effectiveness: Information not available.

Summary of Energy-saving at Home subsidy scheme (SEEH)	
Were SMART objectives set?	No – objective to encourage homeowners to upgrade energy efficiency performance of their homes.
Were the objectives met?	Considered to be a success – ongoing.
Lessons learnt	Limited control groups.

A4.6.4 The Sustainable Energy Investment Grant (ISDE)

The investment subsidy scheme ISDE (*Investeringssubsidie duurzame energie*) started in 2016. This scheme was based on one of the agreements under the Agreement on Energy for Sustainable Growth form 2013. The scheme is planned for the period 2016-2020. Households and small commercial users can receive an allowance for the purchase of heat pumps, biomass boilers, solar water heaters, pellet stoves and small wood-fired boilers (International Energy Agency, 2019).

Policy lever type: Funding (loans and grants).

Objectives: Subsidise investment in systems such as heat pumps. Encourage the adoption of sustainable heating solutions. Active during the period 2016-2030.

Tenure: Private individuals (both citizens and foreigners with a holiday home in the Netherlands). There is a separate arrangement for business users.

Measures: Subsidy for systems such as heat pumps, biomass boilers, solar water heaters, pellet stoves and small wood-fired boilers. The amount of the subsidy depends on the type of the device and the energy performance. For heat pumps, the subsidy is indicatively between €500-2,500.

Delivery mechanism: Led by the Dutch Government. Participants receive money back after purchase.

Funding pathway: In 2016 and 2017 the budget was € 70 million/year; in 2018 and 2019 the budget is €100 million/year (International Energy Agency, 2019).

Challenges: The estimated value of all applications received in 2019 was €176m, thus higher than the available budget. The evaluation concluded that it would be pro-economic to abolish the subsidy for biomass boilers and pellet stoves (Directoraat-generaal Klimaat en Energie, 2019) as they result in extra emissions of nitrogen oxides, particulates, and carbon monoxide. Generally, the effectiveness and scaling opportunities for the scheme were deemed difficult

to determine due to the fact that there is no control group with parties that have invested without a subsidy.

Effectiveness: In the period 2016 to 2018, a subsidy of ca. €215m was provided, which contributed to the purchase of 114,000 devices. These devices produce a total of ca. 5.3 PJ of renewable energy per year, corresponding to an annual CO_2 savings of around 0.3 Mt. The share of applications from private individuals in this period amounted to 90% of all devices applied for. The scheme is considered very positively due to the limited administrative burden for business and the relatively low implementation costs of the ISDE (Directoraat-generaal Klimaat en Energie, 2019).

Cost effectiveness: 25 kJ of renewable energy was produced for each Euro invested.

Summary of the Sustainable Energy Investment Grant (ISDE)	
Were SMART objectives set?	No – objective to encourage uptake of sustainable heating solutions.
Were the objectives met?	Considered to be effective.
Lessons learnt	No control group with parties that have invested without a subsidy.

A4.6.5 Incentive scheme for energy performance in the rental sector (STEP)

The STEP (*Stimuleringsregeling energieprestatie huursector*) was a scheme based on financial incentives and subsidies for the rental sector based on the Energy Agreement. It was active between the 1st of July 2014 and the end of 2018. This scheme is directly linked with the Energy Agreement, which states that all social rental sector properties should have an average label B and a minimum label C should be guaranteed in 80% of private rental properties. The total housing costs (rent, service costs and energy costs) cannot be increased due to the renovation.

Policy lever type: Funding (in the form of grants).

Objectives: Contribute to the objectives of the agreement on energy saving in the rental sector. Encourage short-term investments to make residential rental properties energy-efficient. The scheme does not specify the measures to be subsidised, but rather its extent depends on the achieved performance. For example, if the dwelling was originally Energy Index 2.11 and after the renovation it achieved Energy Index 1.40, the subsidy would be roughly €2,000. Conversely, about €4,500 would be granted to a home improving from Energy Index 2.71 to 1.20.

Tenure: Residential rental sector below the rental limit of ca. €710/month (mostly social rental sector).

Measures: Subsidy. Very energy efficient homes (renovations that exceed the Energy Index of 1.20), Nearly zero-energy buildings (NZEB) or energy-neutral homes receive a greater subsidy as of 1 July 2016.

Delivery mechanism: Grants from the Dutch Government to housing associations and (private) landlords of houses.

Funding pathway: Dutch Government-funded with 395m Euros every year for investments in energy-efficiency in the 2014-2017 period.

Challenges: The number of intended label steps has not been fully achieved, partly as a result of the interim expansion of the scheme. Nevertheless, the STEP scheme is still considered effective.

Effectiveness: The scheme was effective: the €395m budget was fully exhausted, with a grant application for 157,604 homes. A total of 4782 applications were processed through the STEP scheme, with a large majority (84%) of applications coming from housing corporations. The scheme was well-known and appreciated according to the customer satisfaction survey conducted by RVO.nl. Approximately 93,000 tons/year were saved thanks to the implementation of the STEP scheme (Meurs *et al.*, 2019). A high number of homes went from label D or E to A.

Cost effectiveness: 0.25 $kgCO_2$ were saved for each Euro invested.

Summary of Incentive scheme for energy performance in the rental sector (STEP)	
Were SMART objectives set?	No – objective to contribute to objective of agreement on energy saving in rental sector.
Were the objectives met?	Considered to be effective.
Lessons learnt	None apparent from available information.

A4.6.6 Energy Investment Allowance (EIA)

The Energy Investment Allowance (*Energie-investeringsaftrek,* EIA) is a government tax scheme which provides support for investments in energy saving equipment and sustainable energy. Companies making use of the EIA gain a double benefit: lower energy costs and less tax.

Policy lever type: Tax relief incentives.

Objectives: Encourage investment in energy-efficient technologies and sustainable energy in non-residential properties.

Tenure: Non-residential properties.

Measures: Tax benefit for companies if they invest in energy-efficient technologies and sustainable energy. In addition to the deduction of the customary depreciation, beneficiaries may also deduct 45% of the investment cost of energy saving equipment from taxable profit. Consequently, they pay less income tax or corporation tax. Average tax reduction of 11%, plus lower energy bills resulting from the investment.

Delivery mechanism: Government-led tax benefit. For each type of equipment, a digital application must be submitted via RVO.nl's eLoket. RVO assesses the application and issues a declaration confirming that a given investment is eligible for the EIA. The exact amount

that is eligible for the EIA is specified in the declaration. Each business can qualify for the EIA for energy investments of a minimum of €2,500 and a maximum of €121 million in a calendar year. 45% of the amount of the investment cost for which an EIA declaration is received may be deducted from the taxable profit.

Funding pathway: Government-funded. The budget for the EIA in 2019 was €147m.

Challenges: Information not available.

Effectiveness: The total estimated energy saving for this scheme back in 2007 amounts to between 3,230 TJ and 10,352 TJ per year (Aalbers *et al.*, 2007).

Cost effectiveness: Updated information not available.

Summary of Energy Investment Allowance (EIA) for landlords	
Were SMART objectives set?	No – objective to encourage investment in energy-efficient technologies and sustainable energy in non-residential buildings.
Were the objectives met?	Considered to be effective.
Lessons learnt	None apparent from available information.

A4.7 Summary of geographical approach

We have provided a breakdown of the approach that different geographical regions have taken with regards to energy efficiency policy in Section 5 of this report. Table 37 provides a comparison of the approach in each geography.

Table 37: Summary of geographical approach

Geography	Approach	Responsibilities	Targets and strategies	Minimum standards (for new builds)	Policy comprehensiveness
Northern Ireland	Approach to 2020 set out in Strategic Energy Framework 2010. New Energy Strategy for NI currently under development.	Overseen by multiple government departments, with responsibility for ensuring implementation of the EED lying with DfE.	There is currently no energy efficiency target for NI, although it contributes to the UK target.	Covered by Building Regulations, Technical Booklet F, comprising F1 (dwellings) and F2 (buildings other than dwellings).	Policy levers have been comprehensive in addressing sectors and tenure types, but a strategic approach has not been implemented specifically for energy efficiency.
UK	Approach is set out in the 2012 and 2013 Energy Efficiency Strategy and Update. The UK's National Energy Efficiency Action Plan sets out how the implementation of the EU EED will help realise the UK's cost-effective energy efficiency potential.	Overseen by single central government department (BEIS). In general, the EED has been implemented on a UK-wide basis. However, in a number of areas, where the Devolved Administrations in NI, Wales and Scotland have responsibility for implementation, legislation has been adopted by the Devolved Administrations.	A 20% reduction in primary energy consumption (18% reduction in final energy consumption) against 2007 business as usual projections and a 26% reduction in final energy intensity based on policy packages outlined in the Strategy.	Zero-carbon new homes committed from 2016 but this was abandoned. Consultation undertaken October 2019 – February 2020 to inform changes to regulations (Future Homes Standard). Minimum energy efficiency standard rating for private rented residential and non-domestic is E.	Suite of policies set out in the Strategy addresses different sectors and tenure types (although did not target social housing directly). However, as noted in Section 5, these policies were not all successful.

Geography	Approach	Responsibilities	Targets and strategies	Minimum standards (for new builds)	Policy comprehensiveness
RoI	Approach is split into a number of different strategy documents for each sector with the Climate Action Plan 2019 setting the overarching strategy. The SEAI provides a central source of information and guidance for homeowners, public sector and businesses. The Long Term Renovation Strategy (2017-2020) sets out a strategy for mobilising investment in the National Building Stock in conjunction with its National Energy Efficiency Action Plan NEEAP). The NEEAP set a national target for 2020 to improve its energy efficiency by 20%.	Overseen by single government department (DCCAE). The SEAI is responsible for measuring energy savings achieved and for implementing many energy efficiency support programmes.	A 20% reduction in primary energy consumption against 2007 business as usual projections, and a 33% energy savings target for the public sector by 2020. The RoI Climate Action Plan, 2019, sets out how the country will meet its EU targets to reduce its carbon emissions by 30 per cent between 2021 and 2030 and lay the foundations for achieving net zero carbon emissions by 2050 (Dept. Communications, Climate Action & Environment, 2019).	New dwellings require a Building Energy Rating of A2.	Policy levers appear to be comprehensive in addressing different sectors and tenure types.
Scotland	Set out in 'Energy Efficient Scotland' routemap which states which policy levers are targeting each tenure type.	Promotion overseen by Scottish Ministers across departments. Regulation overseen by BEIS.	Falls under UK target for reduction by 2020. Time-based targets set for each tenure type.	Expected to issue consultation for revising minimum standards for new builds in Spring 2020.	Policy levers appear to be comprehensive in addressing different sectors and tenure types, however Energy Efficient Scotland programme does not include new builds.

Geography	Approach	Responsibilities	Targets and strategies	Minimum standards (for new builds)	Policy comprehensiveness
Germany	Approach to meet a virtually climate-neutral building stock is set out in 'Energy Efficiency Strategy for Buildings'.	Overseen by one government department, the Federal Ministry of Economic Affairs and Energy (BMWi), which has the responsibility for the implementation of the EED.[25]	Virtually climate neutral building stock by 2050.	Minimum energy standard for new buildings based on thermal envelope and minimum percentage of RES used for heating, domestic hot water and cooling.	Approach appears to be comprehensive with regards to tenure types.
Wales	Approach is set out in Energy Efficiency Strategy. Led by key areas of action, which recognises market failures and recognises the various tenures and sectors that need to be considered.	Promotion overseen by Welsh Ministers. Regulation overseen by BEIS.	Falls under UK target for reduction by 2020. Statutory target to eradicate fuel poverty as far as reasonably practicable by 2018.	At the time of writing, a consultation for revising minimum standards for new builds was out.	Policy levers implemented to date focus mainly on addressing fuel poverty. Policy levers relating to business are mainly in the form of information and advice support.

[25] Furthermore, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is involved in the implementation of selected areas of the directive. The Federal Energy Efficiency Center (BfEE) within the Federal Office for Economic Affairs and Export Control (BAFA) is mandated by national law to fulfil reporting and monitoring, as well as communication activities. The BfEE also selects and oversees institutions which conduct energy efficiency research for the ministries. Provisions in the EED concerning the energy market and grids lie within the responsibility of the Bundesnetzagentur (BNetzA). The BAFA, the KfW and different project executing bodies implement energy efficiency measures, initiatives and programs for the ministries. (CA EED, 2016a)

Geography	Approach	Responsibilities	Targets and strategies	Minimum standards (for new builds)	Policy comprehensiveness
The Netherlands	Approach is set out in the overarching Climate Agreement which sets out sector specific commitments for the built environment in the context of carbon emissions reduction.	The implementation of the Directive on Energy Efficiency (EED) is the responsibility of the Ministry of Economic Affairs. Also, the Ministry of the Interior and Kingdom Relations and the Ministry of Infrastructure and the Environment are involved in the implementation of the EED. The Netherlands Enterprise Agency (RVO.nl) implements several instruments and programmes related to energy efficiency in assignment of the Ministries.	To achieve carbon reduction targets by 2030, 1.5 million homes will need to be upgraded and emissions cut in existing non-residential buildings by a total of 1Mt by 2030	New residential properties must be designed in a way that no more than $1000m^3$ of natural gas is required each year for heating, hot water and cooking.	Comprehensive in addressing residential and non-residential buildings.

A4.8 Other geographies

Beyond the countries investigated in this report, there are a variety of different policy mechanisms used across the world for implementing energy efficiency. It is beyond the scope of this study to carry out an exhaustive global review. However, based on key internationally focused literature, such as the International Energy Agency (IEA) and the expertise within the project team, some of examples from other geographies are presented in this section.

A4.8.1 Other regions in Europe

The EBRD's Ukraine Energy Efficiency Programme (UKEEP) supports small and medium-sized enterprises (SMEs) to improve their energy efficiency through connecting financiers, advisors and private companies to provide targeted financing and technical expertise.

As part of the National Energy Efficiency Action Plan, Portugal has implemented the Call 20 FEE programme provided direct subsidies for energy efficiency measures in both residential and service buildings. This financed the implementation of existing residential buildings through solar thermal heating, efficient windows, insulation and efficient lighting (ADENE, 2018). As of 2019, this programme has implemented improvements in 695 households and 58 service buildings, achieving energy savings of 303 toe (tonnes of oil equivalent) per year (IEA, 2019).

A4.8.2 New Zealand

New Zealand has county-wide governmental energy strategies which are focused on achieving a low-emission economy and meeting their longer-term goals such as reducing greenhouse gas emissions by 30% below 2005 levels by 2030 (EECA, 2020) . A key strategy is the New Zealand Energy Efficiency and Conservation Strategy (NZEECS) 2017-2022 (MBIE, 2017). It has three priority areas:

- Efficient use of process heat, with an aim to decrease in industrial emissions intensity by 1% per annum by 2022;
- Efficient low emission transport, with an aim for electric vehicles to make by 2% of the fleet by 2021; and
- Innovative and inefficient use of electricity, with an aim that 90% of electricity will be generated by renewables by 2025.

The strategy sets out actions that businesses, individuals and public sector agencies can adopt and how central government can support this. This includes introducing new minimum energy standards for commercial buildings, new and existing homes, appliances, equipment and vehicles, implementation of the Residential Tenancies Act which requires landlords to insulate residential homes, the EECA's Warm Up New Zealand: Healthy Homes programme which ensures quality insulation installation. There is also the Warmer Kiwi homes programme which offers grants to cover 66% of ceiling and underfloor insulation (including installation, as at March 2020).

A4.8.3 North America

In the US, energy benchmarking and disclosure is used as a market-based policy tool to drive demand for energy efficiency improvements. It is predominantly delivered at a local (city)

level. For example, the New York City Local Law 84, Greener Greater Buildings Plan requires owners of large building owners to submit data on annual energy use to the city and is used to create an energy rating for buildings (NYC, 2012). New York also has incentives such as the ConEd residential Energy Efficiency Incentives programme which offer rebates to households that purchase energy efficient appliances (ConEdison, 2020).

In 2019, New York City Council passed their 'Green New Deal' that includes a number of environmentally focused initiatives. It includes a law that sets carbon emissions limits for most buildings over 25,000 square feet and alternative compliance paths for certain types of buildings. The law covers nearly 60,000 buildings. Limits from 2024-2029 will affect the most carbon-intensive 20% of buildings. Limits from 2030-2034 are set to affect the most carbon-intensive 75% of buildings. The emissions reduction goal for buildings is 40% by 2030 and 80% by 2050, with respect to 2005. The target is more demanding for city-owned buildings: 40% by 2025 and 50% by 2030.

A5 Behavioural change

A5.1 Introduction

Behaviours have been identified as a key market system failure. We therefore recognise that there is merit to further exploration of this topic.

People and their behaviours play a key role in the efficiency of buildings' energy performance. We can distinguish two types of behaviours:

1 the day-to-day occupant behaviours, or the actions people perform while using/occupying a building that influence energy performance, and

2 the attitudes towards improvements of building performance, such as the adoption of low-carbon heating systems or the decision to perform a refurbishment.

When discussing people's acceptance of energy policies, it is the second type of behaviour – the attitudes – that have a major role. Progress in retrofitting programs and decarbonising existing homes through low-carbon heating systems (such as hybrid heat pumps) would benefit from greater acceptance and demand from consumers. Consumer adoption could also stimulate innovation in products and services and accelerate commercialisation and cost reduction (Carmichael, 2019). At the same time, the day-to-day interactions should also be considered to have a better understanding of the actual energy performance and prevent the *rebound effect*, whereby a reduction in expected savings from energy-efficient technologies is witnessed because of behavioural or other systemic responses.

Both types of behaviours are thus shortly described below.

A5.2 Day-to-day occupant behaviours

So-called occupant behaviour (OB) includes the physical presence of occupants, as well as their actions that have an influence on the energy use and thermophysical behaviour of a building, such as using plug-loads, operating windows and shading devices, setting thermostats, etc.

How occupants behave can have a dramatic effect on a building's energy and comfort performance. Figure 41 (Gaetani *et al.*, 2020) shows the difference between the highest and lowest consumers in heating energy (Figure 41a) and total energy (Figure 41b) in terms of ratio in identical buildings where the sole difference are the occupants.

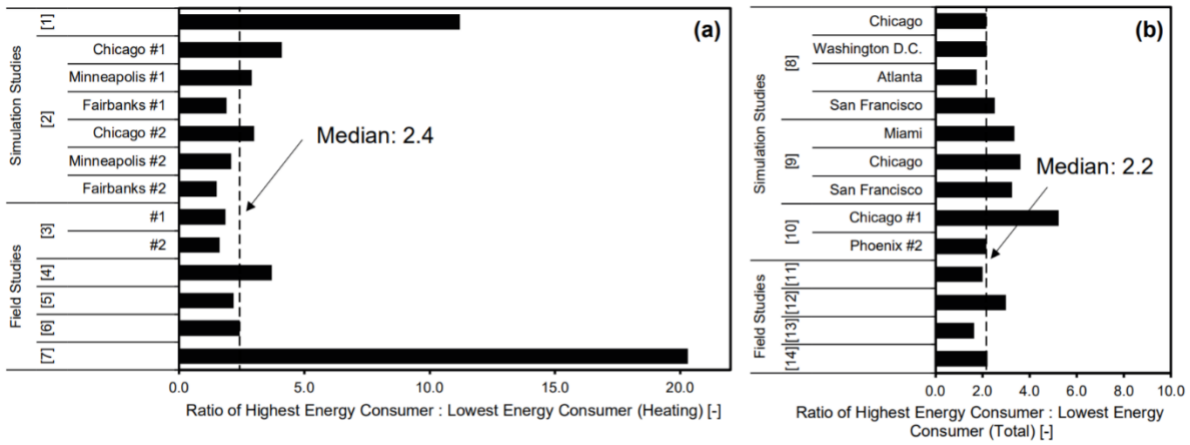


Figure 41: Ratio of highest energy consumer to lowest heating energy (a) and total energy (b) consumer in identical buildings due to OB only. Climate and #n indicate where different buildings investigated in the same publication.

Figure 41a includes two simulation studies ((Gaetani, Hoes and Hensen, 2016) [1]; (Lin and Hong, 2013) [2]) and five field studies ((Morley and Hazas, 2011) [3]; (Gram-Hanssen, 2010) [4]; (Maier, Krzaczek and Tejchman, 2009) [5]; (Gaunt and Berggren, 1983) [6]; (Andersen, 2012) [7]), while Figure 41b presents the outcome of three simulation studies ((Wang, Mathew and Pang, 2012) [8]; (Hong and Lin, 2012) [9]; (Clevenger, Haymaker and Jalili, 2014) [10]) and four field studies ((Norford *et al.*, 1994) [11]; (Lutzenhiser, 1993) [9]; (Muroni *et al.*, 2019) [12]; (Sonderegger, 1978) [13]).

On average, a ratio of about 1:4.5 (heating energy) and 1:3 (total energy) between identical buildings using the least and the most energy was observed due to differences in OB alone. Conversely, the median values (reported in the figure) are 2.4 and 2.2 for heating energy and total energy, respectively. These results mean that we can *expect* identical buildings to have up to threefold difference in energy use due to OB. These values give an impression of the potential uncertainty in the energy performance caused by day-to-day occupant behaviours. However, Figure 41 also shows the high variability of OB influence among different studies.

The different studies investigated diverse buildings, climates, occupants, and available interactions between occupants and building. It is impossible to define a priori what the influence of OB on building performance may be. Generally, day-to-day behaviours are expected to have a larger impact in residential buildings compared to non-residential buildings, since people tend to have less influence on energy use in the latter. However, the figure above and the literature also show the important impact of OB in non-residential buildings, often due to sub-optimal facilities management. Small changes in company culture, such as relaxing the dress-code and increasing the acceptable temperature band, can lead to significant energy savings (Tsushima, Tanabe and Utsumi, 2015).

What is important to note, however, is that the influence of certain aspects of OB on building performance increases as building envelopes and systems are optimised, technical performance standards become tighter and low-energy systems become more widespread (Clevenger and Haymaker, 2006). This is extremely relevant when we work towards increasing the energy efficiency of an entire country's building stock. The more energy-efficient the building, the more attention needs to be paid to the impact of OB on building performance to ensure that it is not compromising the original intention and that the energy variations we witness are within the expected limits.

A5.3 Attitudes towards improvements of building performance

By adopting energy efficiency measures, single households can make relevant contributions to saving energy and reducing GHG emissions (Ameli and Brandt, 2015). Yet, the determinants of such adoption and the factors behind consumer choice are extremely complex. The attitudes of building occupants are essential for the successful implementation of energy-efficiency policies.

Such attitudes, however, are shaped by a myriad of factors, from households' socio-economic characteristics, to characteristics of their dwellings, to attitudes regarding environmental problems and social practices, to policy and economic context (Trotta, 2018).

For example, a generally positive correlation between *income* and the probability of investing in energy technologies is observed (Mills and Schleich, 2012; Ameli and Brandt, 2015). This indicates the existence of credit constraints for some technologies. Many energy efficiency investments have high initial investment costs representing a relevant barrier, especially for low-income, fuel-poor households, who are more likely to be credit-constrained. Individuals with higher levels of education and with children appeared more likely to adopt energy efficiency measures.

Another driver of technology adoption is *ownership*. Renters have much weaker incentives to invest than owners (Ameli and Brandt, 2015). A survey circulated among 1500 Irish residents revealed that the share of residents who did not think they needed to reduce energy use as energy is not a top priority was 8% among owner-occupiers and 19% among tenants/landlords SEAI (2017). This points towards 'landlord/tenant split incentives' a common market failure, and relevant for NI where an estimated 17% of households live in rented accommodation (NIHE, 2018). Owner-occupied dwellings are more likely to be insulated than renter-occupied dwellings, and owners tend to own more energy-efficient home appliances, heat thermostats, heat pumps. Immobile investments (such as energy-efficient windows and thermal insulation) are particularly more likely by owners, while renters tend to invest in more mobile technologies (e.g., light bulbs). Moreover, households are more likely to invest in energy upgrades when they first move into their home (Ameli and Brandt, 2015).

A very important factor is the *access to information* regarding energy-efficient solutions and how such information is processed (bounded rationality, whereby customers use only a subset of the available information for decision-making processes, is very common). How profitable will a given investment be? What are the costs and benefits of different energy solutions? What rates of return can one expect from energy efficiency measures? Unawareness and misperceptions are known deterrents for investments in energy-efficient technologies. When knowledge is more accessible, for example when appliances are metered and displayed in the house, households are more likely to invest in energy-efficiency. SEAI (2017) found out that more than 10% of Irish consumers in the residential sector think they could reduce energy use but they need more information.

A5.4 Policy implications

Behaviours have evident implications on the success of policies' implementation. From the literature review, three key lessons learnt emerge (Ameli and Brandt, 2015; Trotta, 2018; Carmichael, 2019; Hesselink and Chappin, 2019):

Target policies to address specific behavioural barriers for different groups of consumers

- Governments should know well their consumers and address their varying needs with different policies. This includes having appropriate proxy indicators of the targeted households. Failing to do so can result in mistargeting the policies (as it happened, for example to the ECO scheme in Great Britain (Trotta, 2018), where most funds were spent for households that were not in fuel poverty). For example, SEAI (2017) was able to realise more targeted retrofits of homes in Ireland by identifying three consumer segments: aspirational, comfort and value seekers, and cost-driven.
- Credit constraints could deter some consumer segments (such as young, low-income and single households living in fuel poverty, which is particularly relevant to NI) from investing. For these consumer segments, the upfront costs of energy investments could be lowered by financial incentives such as direct subsidies, tax credits or rebates.
- Specific policies are required for the rental housing market, which represents 17% of the NI housing market. Private landlords often don't see the benefits of energy efficiency due to 'split incentives' SEAI (2017). A solution could be to capitalise investments in energy-efficient measures in the purchase and rental prices of a property, so that the owner could recover the investment costs. Owners could also be allowed to increase the rent after implementing energy efficiency measures.

Increase awareness, promote energy conservation actions and influence individual decision-making (Carmichael, 2019)

- Households should be provided with feedback on their energy use; a better understanding of energy practices would be helpful along energy labels. Gans, Alberini and Longo (2012) proved through a large-scale experiment that the potential of information-induced energy efficiency is NI is pronounced. The study found a decline of 15-20% in electricity use after the introduction of feedback displays.
- There should be a centrally-administered system of accreditation for suppliers and installers of low-carbon technologies and refurbishments, so that high quality outcomes are maintained, and consumers gain trust and confidence in the technology. Householder engagement is improved where information and initial contact come from a trusted source, which is perceived as likely to act in their best interests and to provide impartial advice SEAI (2017). It is important to understand who a trusted partner could be.
- Public buildings have a potentially pivotal role to play as showcase projects for low-carbon technology adoption and energy-efficient retrofits. Public buildings should lead the way in the transformation of the building stock, by clearly communicating energy strategies and their relative costs and savings. In NI, the public building stock is already the most data-rich sector in terms of energy use. Such data and energy-efficient retrofits should be benchmarked and clearly communicated to everyone entering the building. There is a unique opportunity to raise awareness by example, and this was also highlighted during stakeholder engagement.
- Some low-income households might choose to save the money resulting from a reduced energy bill, while others may increase the energy consumption (rebound effect)[26]. The

[26] The rebound effect is the erosion of potential energy saving by a behavioural response. This is particularly relevant for fuel poor households as, pre-retrofit, homeowners may not have been able to afford to heat their

rebound effect could have positive impacts on health and thermal comfort, but it diminishes the energy saving intention of the measures. Awareness of such effect would be beneficial for fuel poor households to help them make rational choices.

Maximise the value proposition or 'relative advantage' to consumers through lowering up-front and running costs (Carmichael, 2019)

- The up-front costs of a heat pump, for example, are considered unaffordable by most households at present, with 80% of consumers surveyed reporting they 'would not or could not afford' a hybrid heat pump (HHP) installation (Clarke, 2018).
- Consumers tend to focus on immediate or near-term costs and put less value on longer-term savings and benefits.
- Models with no upfront customer costs (such as the Heat-as-a-Service (HaaS)) are needed to target markets with the largest potential financial savings, such as NI (where around 68% of homes are heated with oil-fired boilers and fuel poverty is around 20%).
- A reduced or zero VAT-rating for all retrofit installations of heat pumps could be another mechanism for lowering upfront costs.
- Hesselink and Chappin (2019) link policies and barriers to the adoption of energy efficiency concepts related to behaviour (see Figure 42). When presenting the various levers that we included in the modelling we will refer to possible associated behavioural barriers.

home sufficiently. Therefore, the carbon saving benefits which may have been assumed through the delivery of retrofit measures are eroded as the home is more adequately heated for the first time (Aydin, et al., 2017).

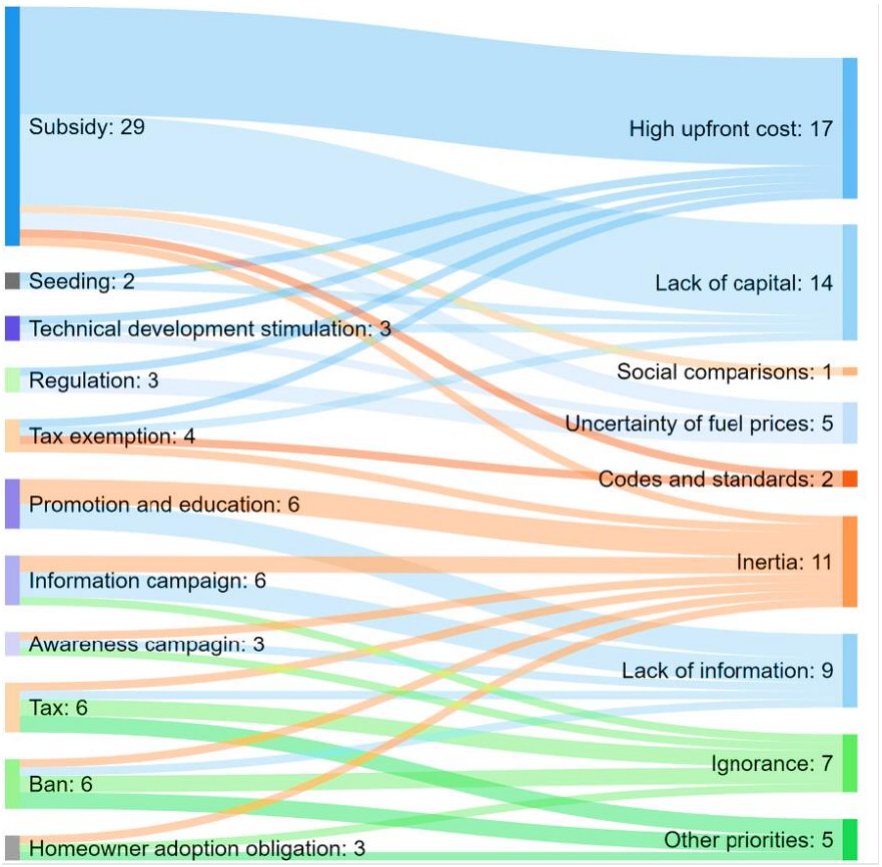


Figure 42: Links between policies (left) and barriers (right) visualised in a Sankey diagram (Hesselink and Chappin, 2019). Numbers refer to the number of different identified policies within each policy category, but the numbers are less significant than the linkages. For instance, high upfront costs and lack of capital are mainly addressed by subsidies, while inertia is addressed by a wide variety of policy approaches.

Appendix B: Stakeholder descriptions

Stakeholder	Description / Responsibilities
Consumer Council NI	The Consumer Council is a non-departmental public body (NDPB) established through the General Consumer Council (Northern Ireland) Order 1984. Its principal statutory duty is to promote and safeguard the interests of consumers in NI. The Consumer Council has specific statutory duties in relation to energy, postal services, transport, and water and sewerage. These include considering consumer complaints and enquiries, carrying out research and educating and informing consumers.
Department of Agriculture, Environment and Rural Affairs (DAERA)	Lead department for climate change. DAERA is also currently developing a Clean Air Strategy, which includes tackling air pollutant emissions from road transport, industry and home heating.
Department for Infrastructure	Main responsibilities: regional strategic planning and development; transport strategy and sustainable transport; public roads; public transport; air and seaports; water and sewerage services.
Department of Finance	Responsible for policy and legislation on building regulations (whilst enforcement is a matter for district councils) and energy performance certification of buildings.
Derry and Strabane District Council	Derry and Strabane District Council was created as part of the 2014 NI local government reform, replacing Derry City Council and Strabane District Council. The area covered by the new council has a population of 147,720 residents according to the 2011 UK census.
Energy Saving Trust NI	Manages the NI Sustainable Energy Programme (NISEP) on behalf of the Utility Regulator. NISEP provides grants to help implement energy-saving measures in domestic and commercial properties, such as grants for energy-efficient boilers, heating, loft insulation and cavity wall insulation.
Federation of Small Businesses (FSB)	FSB is a lobbying organisation representing small firms and the self-employed to UK, national, local and devolved government. FSB offers its members a range of benefits, such as a 24-hour legal advice line and free business banking.
Invest NI	A Non-Departmental Public Body of DfE, with an aim to help new and existing businesses to compete internationally, and attract new investment to NI. Promotes resource efficiency and energy efficiency in the commercial and industrial sector.
National Energy Action NI	Designs and delivers projects to demonstrate new and innovative ways to tackle fuel poverty. Works in partnership with local authorities, housing associations, the health sector, the energy industry, and other public and private organisations. Influences strategic development; enhances delivery capabilities and brings affordable warmth to communities, including through the following programmes: Belfast Warm and Well Project; Northern Exposure; Affordable Warmth; and the Smart Meter Project.
Northern Ireland Authority for Utility Regulation (NIAUR) ("Utility Regulator")	Responsible for regulating the electricity, gas, water and sewerage industries in NI, promoting the short- and long-term interests of consumers. Delivers the Norther Ireland Sustainable Energy Programme (NISEP), which is managed by Energy Saving Trust NI. Aims to contribute to the promotion of sustainable development in exercising its regulatory duties. This includes promotion of efficiency in the use of electricity and gas, and protection of the welfare of electricity, gas and water customers, with due regard for the needs of vulnerable customers.
Northern Ireland Federation of Housing Associations (NIFHA)	The representative body for NI's 20 registered housing associations.

Stakeholder	Description / Responsibilities
Northern Ireland Housing Executive (NIHE)	In its role as the Home Energy Conservation Authority (HECA) for NI, it seeks to strategically plan and support improvements in home energy efficiency across the entire housing stock in the region. This includes carrying out and/or supporting research to promote innovation and help track the progress of energy efficiency programmes and projects. NIHE also has responsibility for the Energy Advice Line, Oil buying clubs, and schools programme.
Northern Ireland Local Government Association (NILGA)	The council led representative body for local authorities in NI.
Queen's University (Centre for Advanced Sustainable Energy)	The Centre for Advanced Sustainable Energy (CASE) is an industry-led sustainable energy research centre. It funds collaborative R&D in sustainable energy, bridging the gap between industry research needs and academic research offerings. It was established in September 2013 to fund collaborative R&D projects in partnership with academics at Queen's University Belfast, University of Ulster and the Agri-Food and Biosciences Institute. It also signposts companies to other grant support through Invest NI, UK Government, the EU and Internationally. The results of CASE R&D also provide a solid base for influencing local government policy in the sustainable energy sector and we proactively promote NI's sustainable energy innovation capability within government circles.
Royal Society of Ulster Architects (RSUA)	The professional body for chartered architects in NI with circa 900 members. It promotes and maintains a high standard of qualification in the profession.
Scottish government	Scotland's Climate Change Plan (Scottish Government, 2018a) sets out that by 2032, improvements to the building fabric of buildings will result in a 15% reduction in domestic heat demand and 20% reduction in non-domestic heat demand respectively. The 'Energy Efficient Scotland' routemap (Scottish Government, 2018b) outlines steps that will be taken under the Energy Efficient Scotland programme to support homes, businesses and public buildings to become more energy efficient over the next 20 years.
Sustainable Energy Authority of Ireland (SEAI)	RoI's national sustainable energy authority, working with homeowners, businesses, communities and government. SEAI's role is to help homes, businesses, communities, and industry to be more energy efficient, and also support the development of clean energy technologies.
University of Edinburgh	University of Edinburgh is working on the evaluation of the Energy Efficient Scotland pilots. This work involves a social evaluation of the retrofitting pilot projects taking place under the Energy Efficient Scotland programme. This interdisciplinary work includes qualitative interviews with local authorities and delivery partners performing building retrofit and surveys with building occupants and users before and after retrofit. The research involves close collaboration with policy makers and a variety of stakeholders involved in the retrofitting process.
University of Ulster	The Centre for Sustainable Technologies at University of Ulster undertakes multidisciplinary research to design, create, develop, improve, demonstrate and evaluate emerging, existing and alternative sustainable renewable energy, building design, construction materials, transport and environmental modification technologies.

Appendix C: Planned or projected growth areas

Table 38: Planned or projected growth areas by district council

Local Council Area	Additional housing units	Timespan	Source
Antrim & Newtownabbey	9750	2015 - 2030	https://issuu.com/anborough/docs/52637forweb
Armagh, Banbridge & Craigavon	19850	04/2015 - 12/2030	https://www.armaghbanbridgecraigavon.gov.uk/download/5657/preferred-options-paper/20702/preferred-options-paper-published-28-march-2018.pdf
Belfast	29660	2020 - 2035	https://yoursay.belfastcity.gov.uk/planning-and-place/belfast-ldp-2035-draft-plan-strategy-equality-impa/supporting_documents/BELFAST%20LDP%20%20DRAFT%20PLAN%20STRATEGY%20%20WEB.pdf
Causeway Coast & Glens	9270	2018 - 2030	https://www.causewaycoastandglens.gov.uk/uploads/general/CCGBC_Local_Development_Plan_2030_-_POP.pdf
Derry & Strabane	9000	2019 - 2032	https://www.derrystrabane.com/Subsites/LDP/LDP-draft-Plan-Strategy-(dPS)
Fermanagh & Omagh	4337	2015 - 2030	https://www.fermanaghomagh.com/services/planning/preferred-options-paper/?download=file&file=15075
Lisburn & Castlereagh	11550	2017 - 2032	https://www.lisburncastlereagh.gov.uk/uploads/business/TECHNICAL_SUPPLEMENT_1_HOUSING_GROWTH_STUDY.pdf
Mid & East Antrim	4614	2018 - 2030	https://www.midandeastantrim.gov.uk/business/planning/local-development-plan
Mid Ulster	6294	2015 - 2030	https://www.midulstercouncil.org/getmedia/dd8d49d7-79a6-4419-948f-2569cb0d0fa5/Local-Development-Plan-2030-Strategy-for-reconsultation.pdf.aspx
Newry, Mourne & Down	13546	2016 - 2030	https://www.newrymournedown.org/media/uploads/nmd_local_development_plan_2030_pop_medium_web_version.pdf
North Down & Ards	8190	2015 - 2030	https://www.ardsandnorthdown.gov.uk/images/assets/ANDBC-POP-Consult-17-May-2019.pdf

Appendix D: Building characteristics by tenure and location

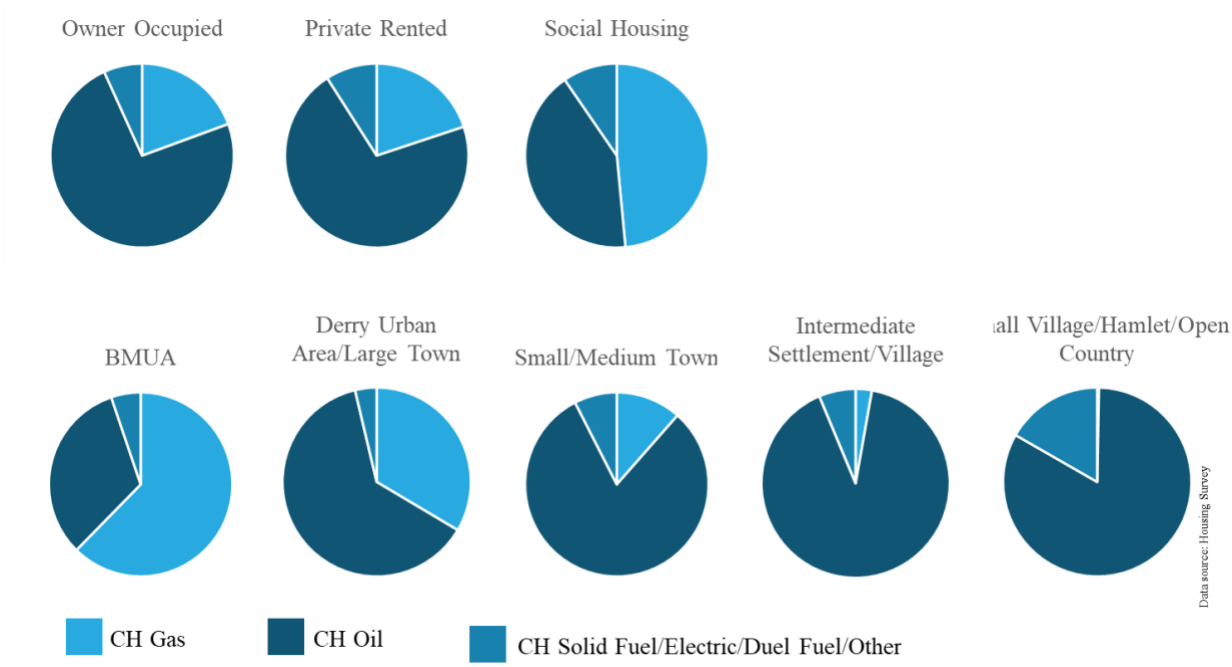


Figure 43: Central Heating type by tenure and location (NIHE and National Statistics, 2016).

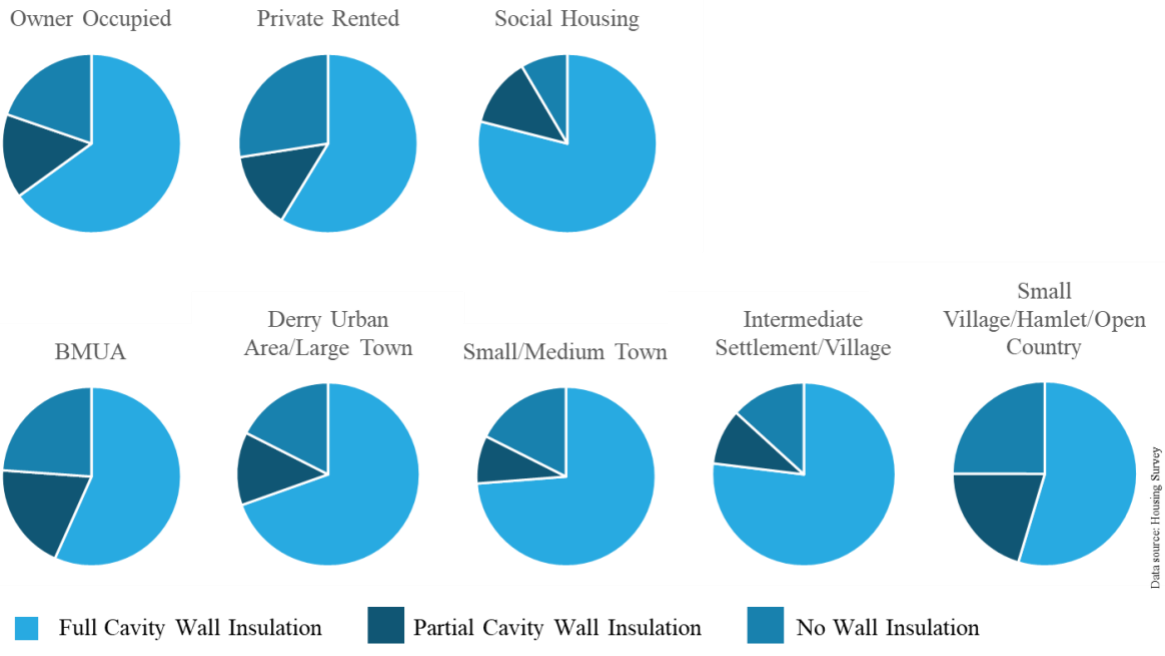


Figure 44: Adoption of cavity wall insulation by tenure and location (NIHE and National Statistics, 2016).

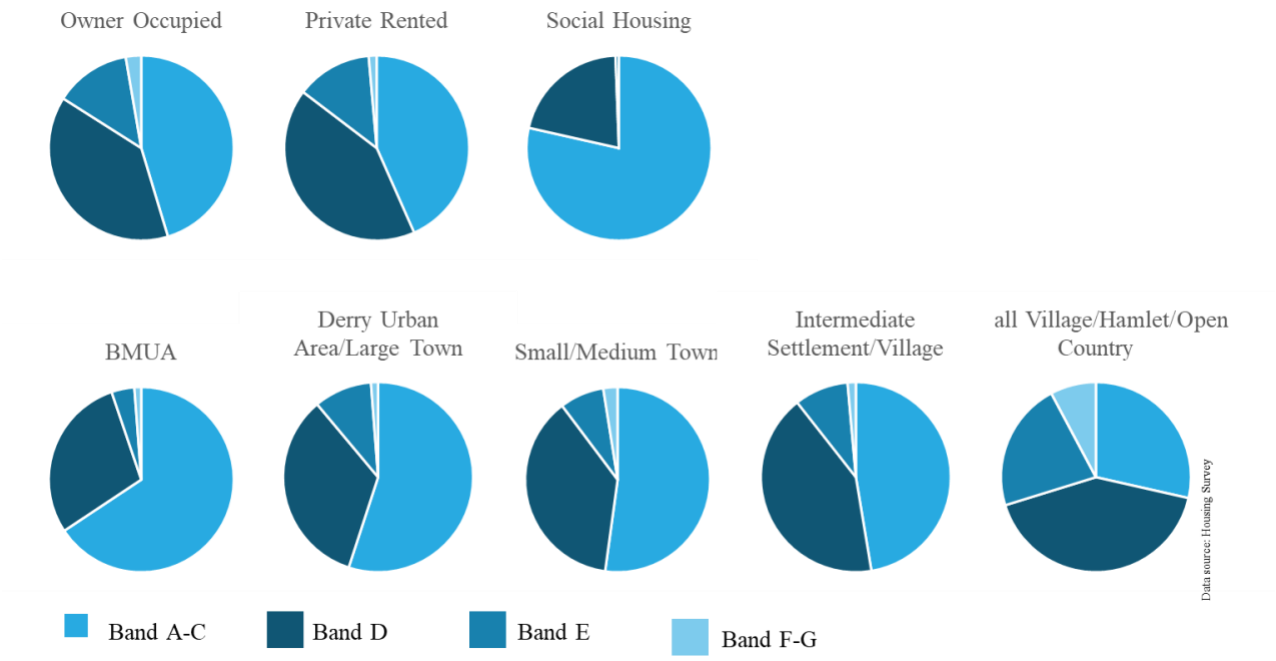


Figure 45: EER by tenure and location (NIHE and National Statistics, 2016).

Appendix E: GIS outputs

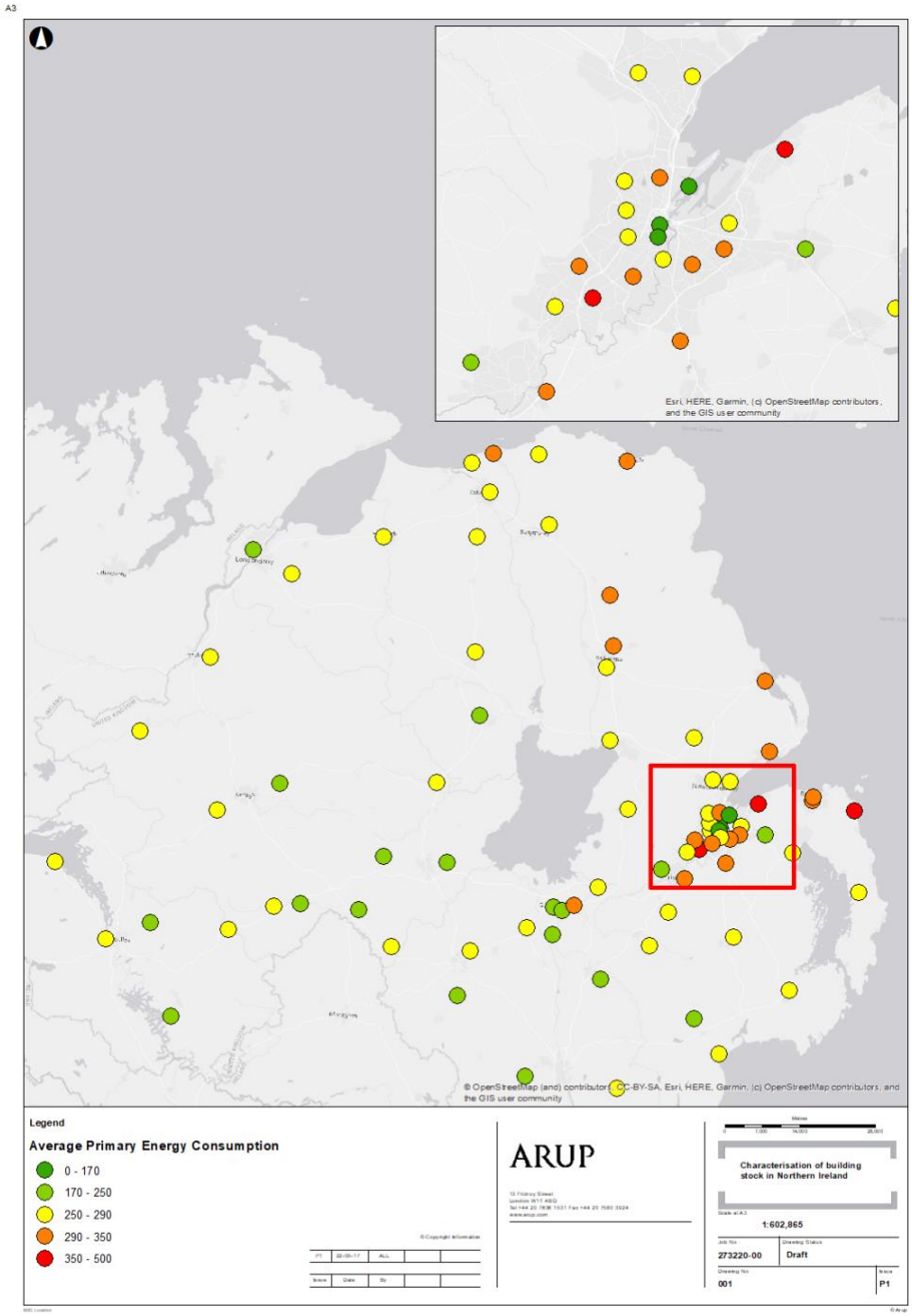


Figure 46: Average annual energy consumption (kWh/m^2 per year) from EPC data by outward code (Department of Finance, 2020)

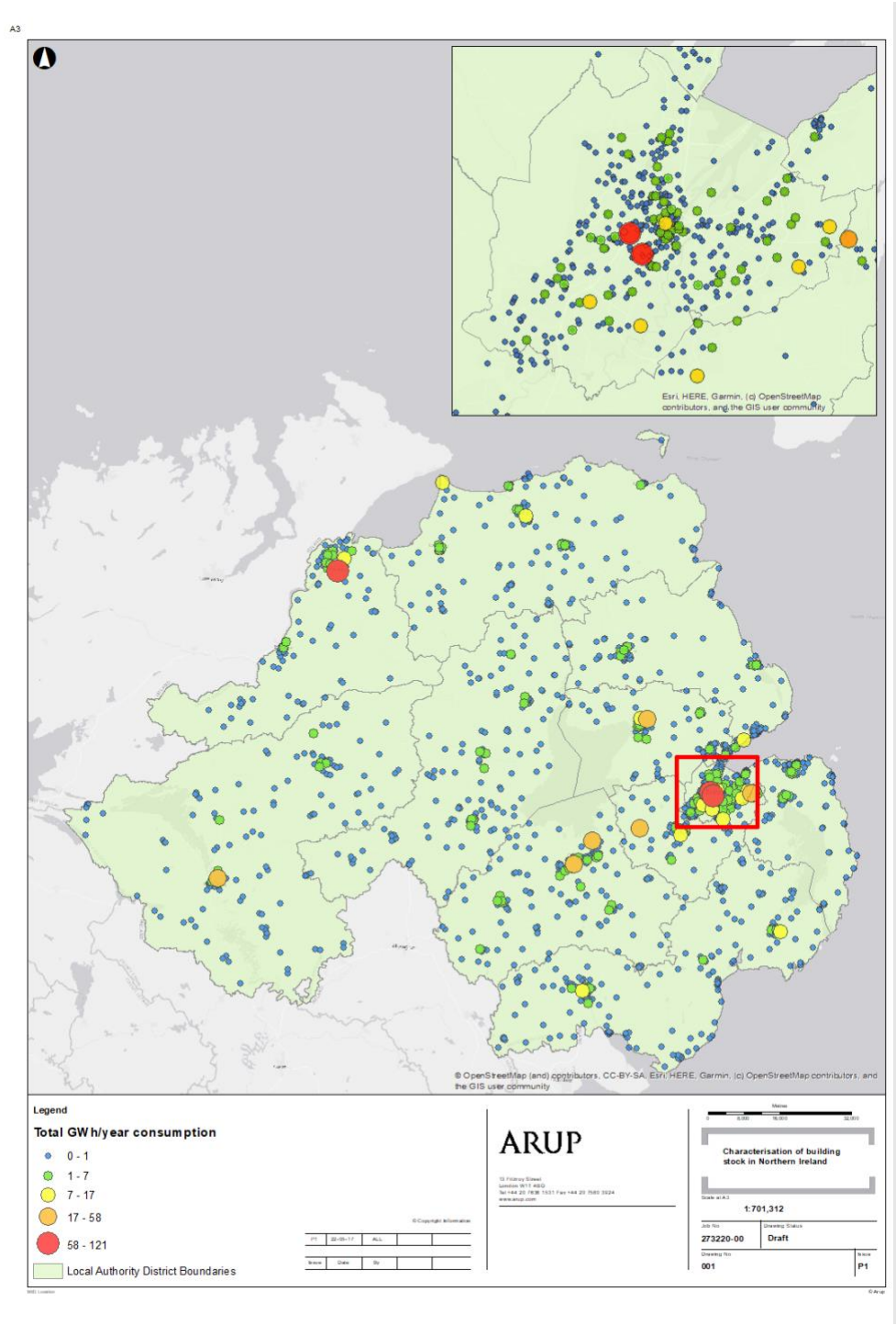


Figure 47: Annual energy consumption (kWh/m^2 per year) from EPC data for government-owned buildings. Only few buildings consume more than 1 GWh/year (Strategic Investment Board (SIB) and NICS Departments, 2020).

Appendix F: Low and Localised scenario results

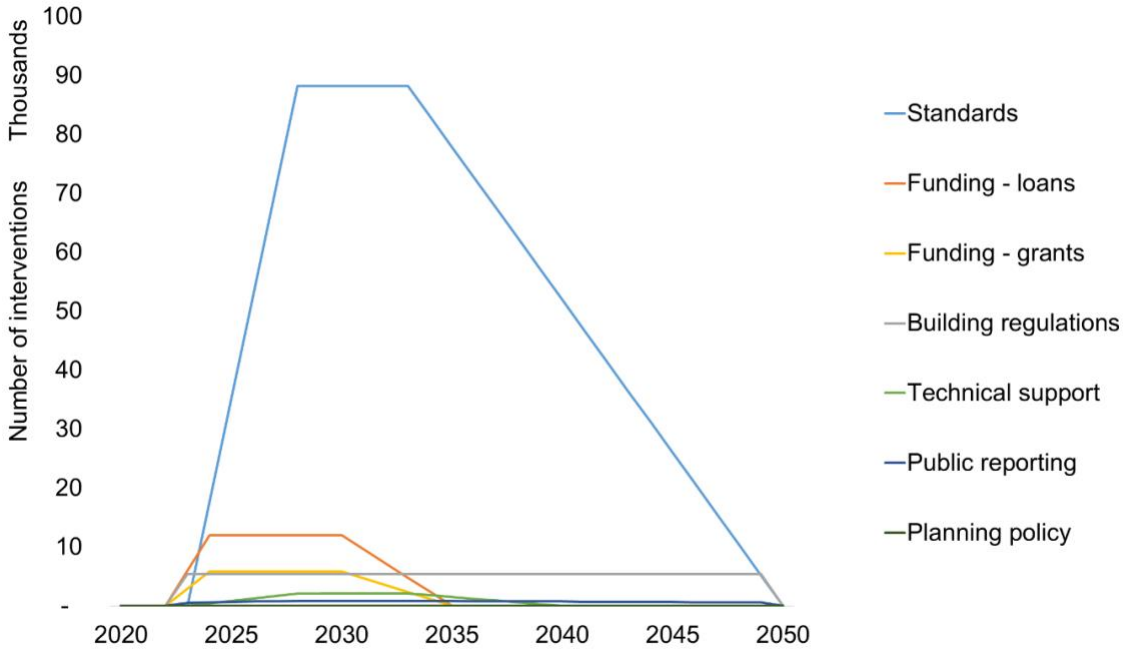


Figure 48: Total domestic interventions for each modelling policy lever under the Low Intervention scenario.

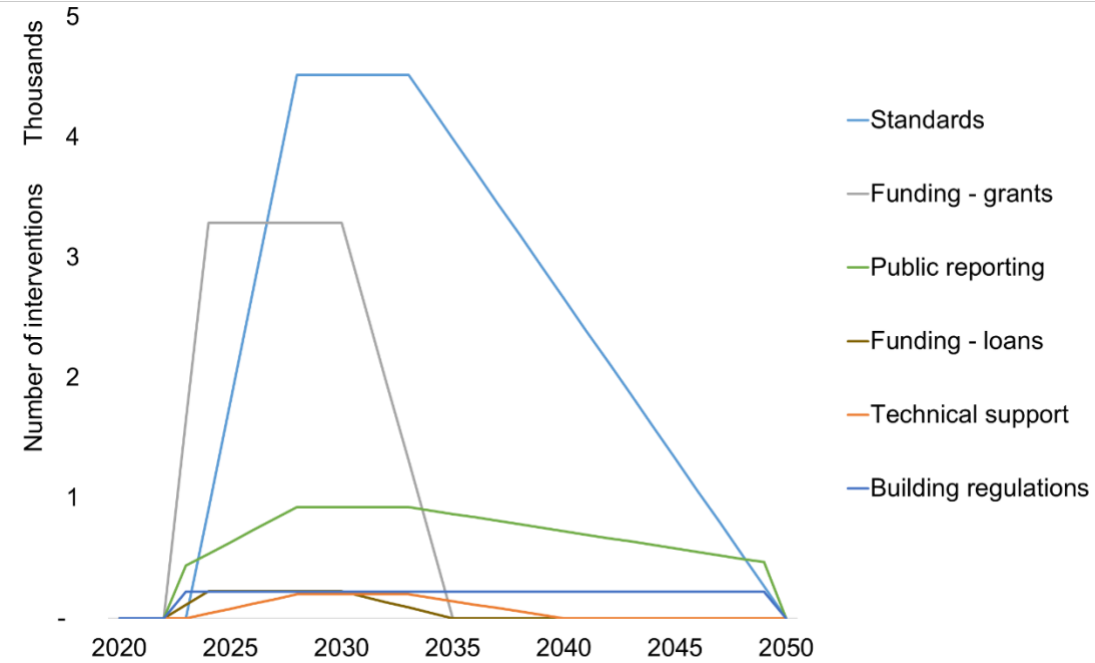


Figure 49: Total non-domestic interventions for each modelling policy lever under the Low Intervention scenario.

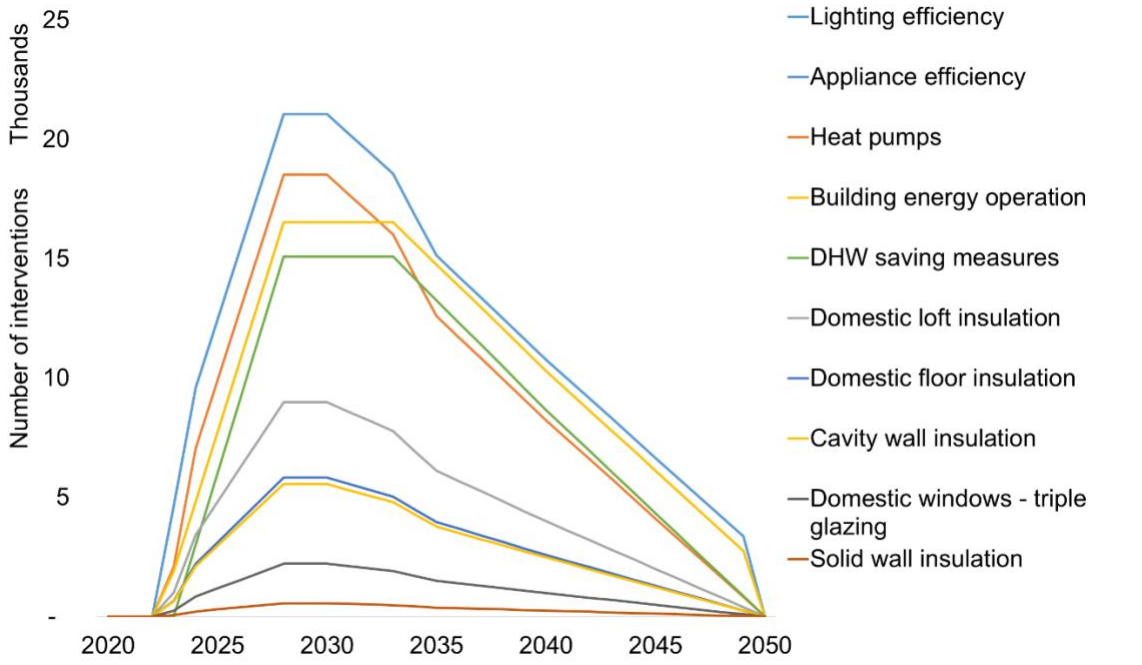


Figure 50: Total domestic interventions for each modelled intervention measure under the Low Intervention scenario.

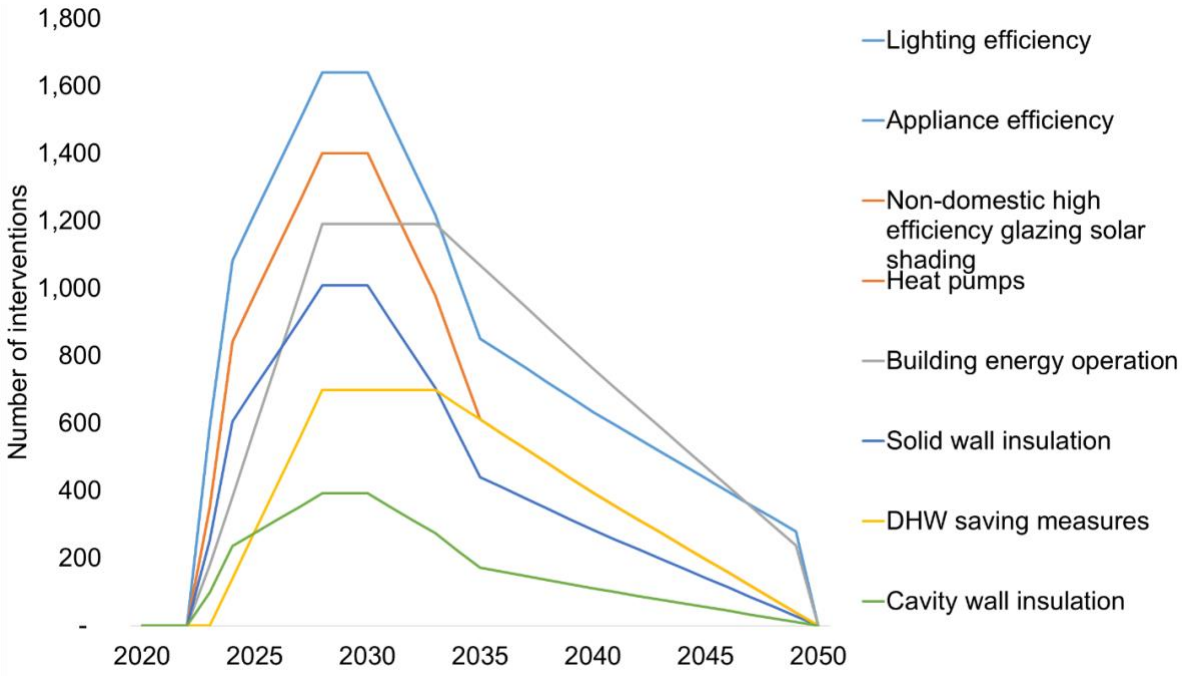


Figure 51: Total non-domestic interventions for each modelled intervention measure under the Low Intervention scenario.

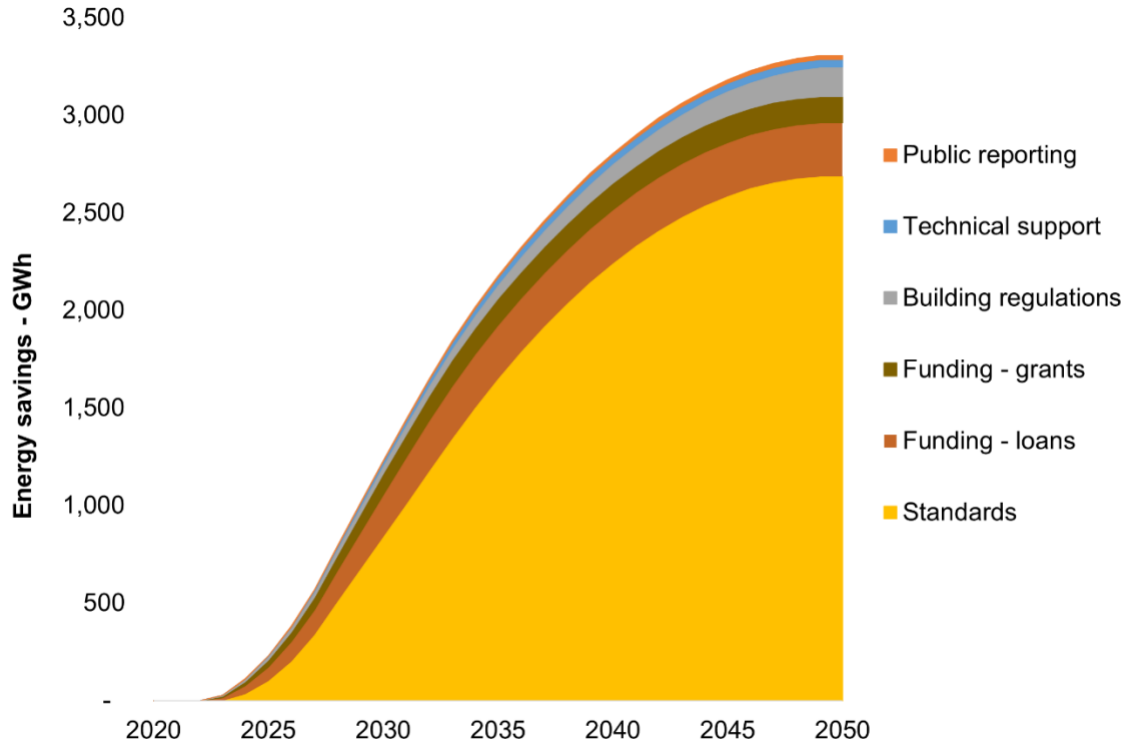


Figure 52: Energy demand reduction by policy lever for domestic buildings under the Low Intervention scenario.

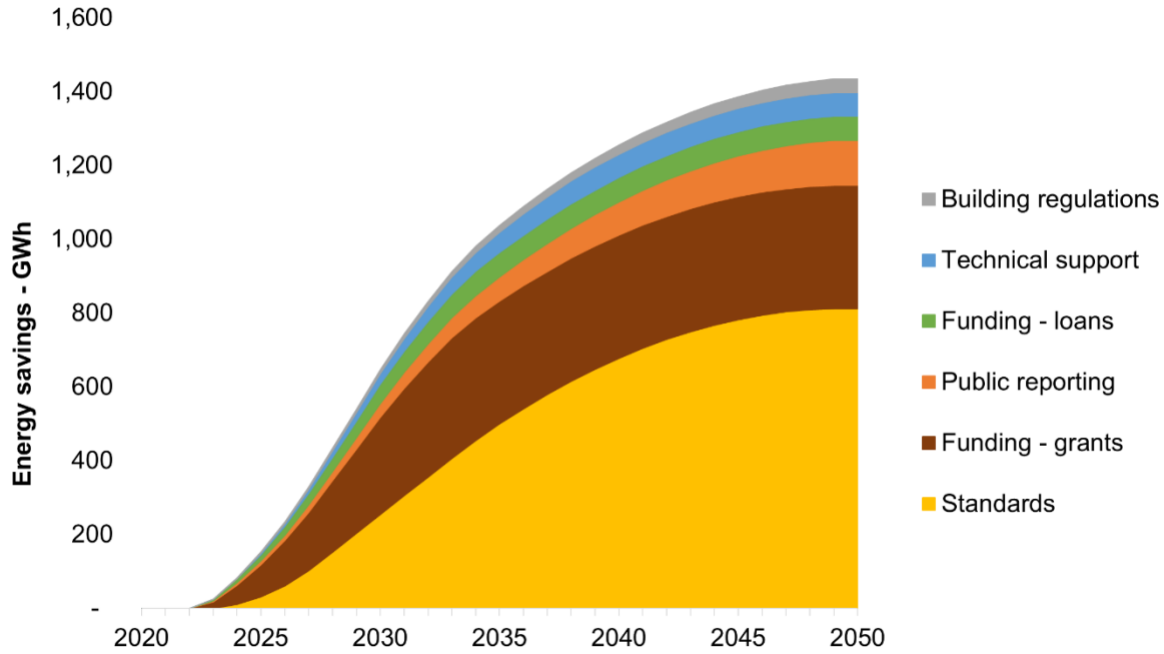


Figure 53: Energy demand reduction by policy lever for non-domestic buildings under the Low Intervention scenario.

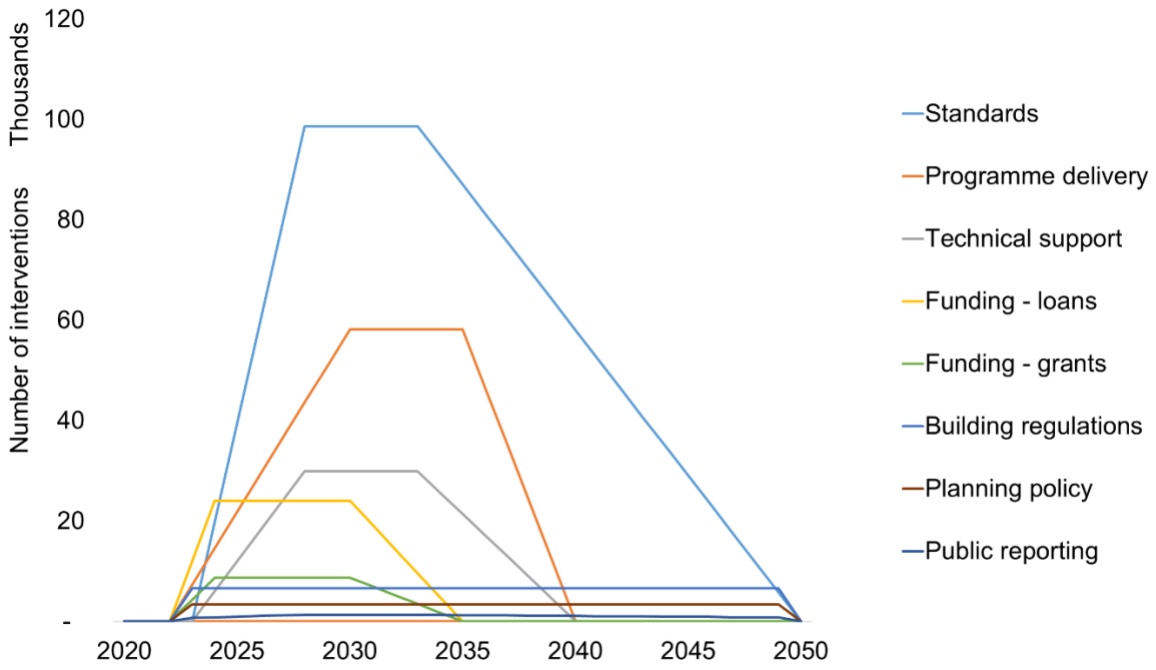


Figure 54: Total domestic interventions for each modelling policy lever under the Localised Intervention scenario.

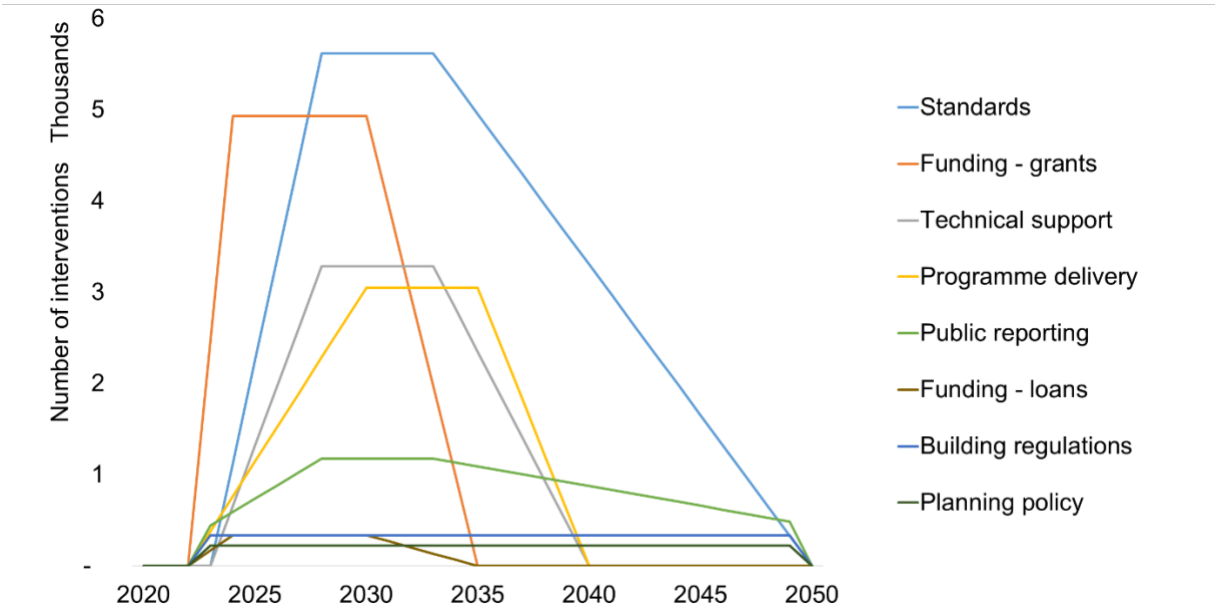


Figure 55: Total non-domestic interventions for each modelling policy lever under the Localised Intervention scenario.

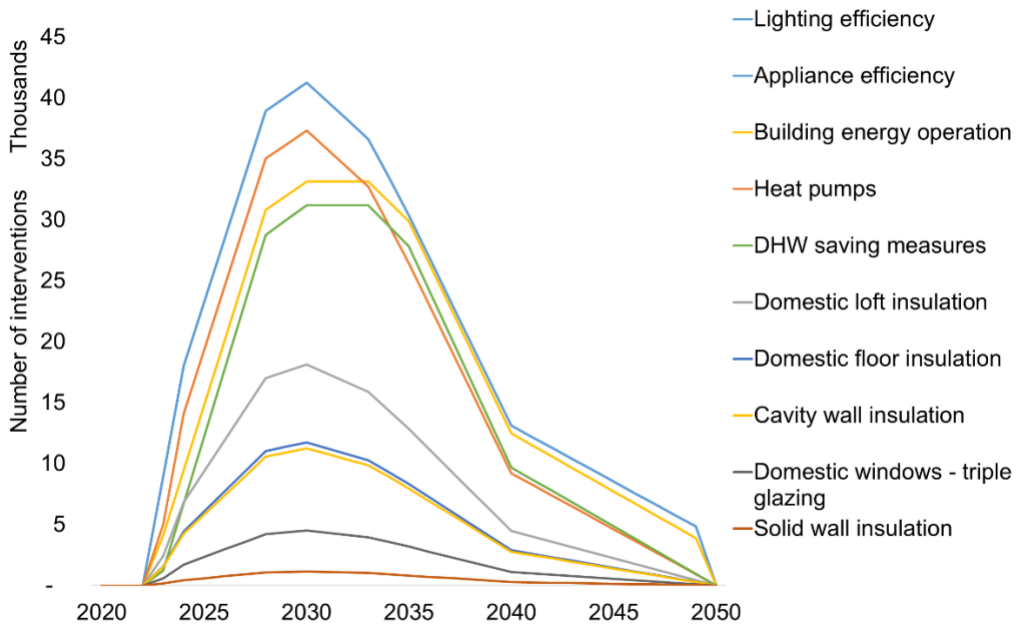


Figure 56: Total domestic interventions for each modelled intervention measure under the Localised Intervention scenario.

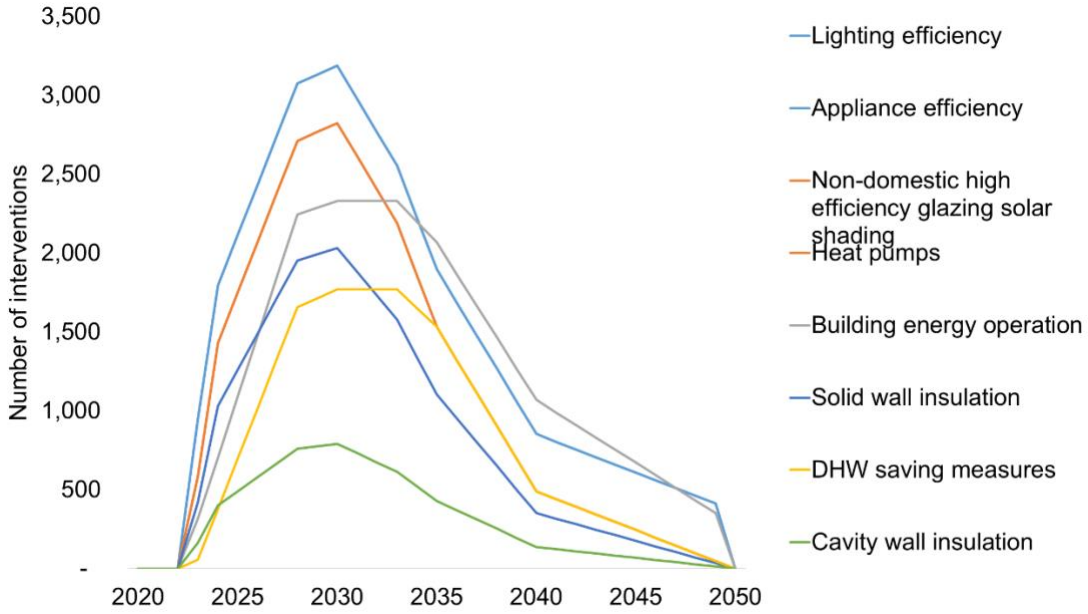


Figure 57: Total non-domestic interventions for each modelled intervention measure under the Localised Intervention scenario.

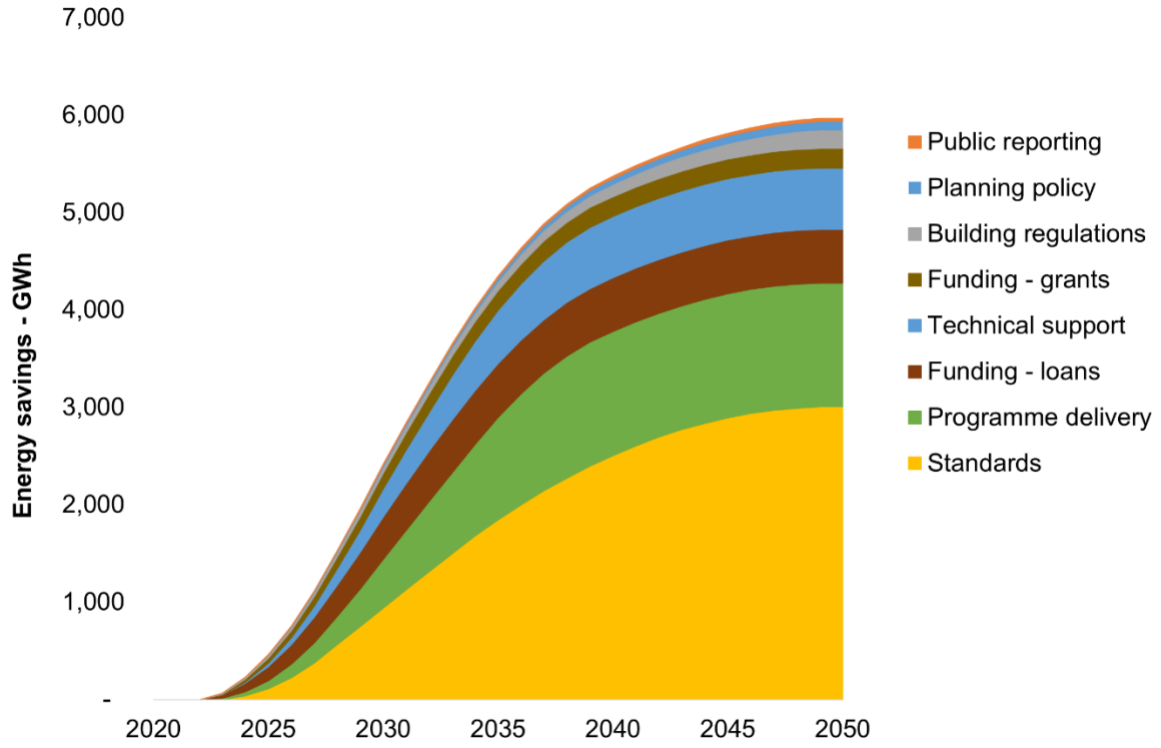


Figure 58: Energy demand reduction by policy lever for domestic buildings under the Localised Intervention scenario.

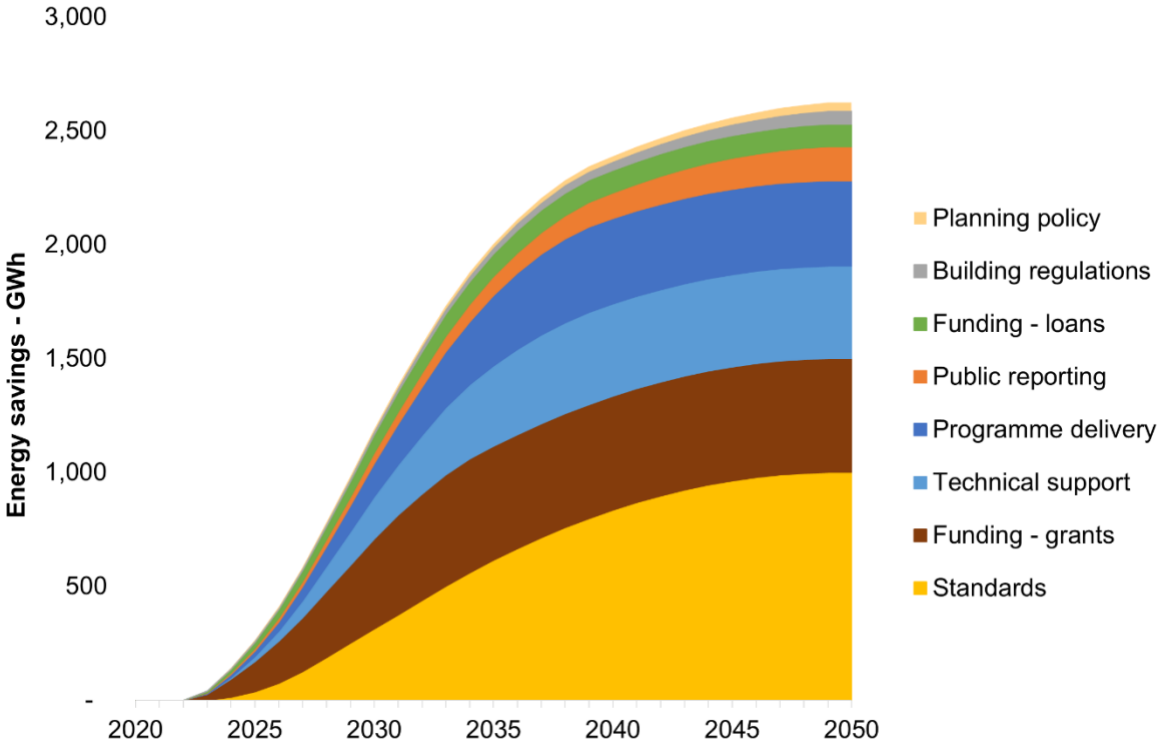


Figure 59: Energy demand reduction by policy lever for non-domestic buildings under the Localised Intervention scenario.

Appendix G: Intervention costs

The total investment costs required for the intervention measures were calculated using cost data collected from suppliers and the Energy Savings Trust (2020)[27], presented in the tables below.

Table 39: Costs of interventions for domestic buildings

Building tenure	Intervention	Cost per intervention
Owned outright	DHW saving measures	£90
Owned with mortgage	DHW saving measures	£90
Shared ownership	DHW saving measures	£80
District owned	DHW saving measures	£80
Social housing assoc.	DHW saving measures	£80
Private rented	DHW saving measures	£80
Owned outright	Building energy operation	£990
Owned with mortgage	Building energy operation	£980
Shared ownership	Building energy operation	£920
District owned	Building energy operation	£920
Social housing assoc.	Building energy operation	£920
Private rented	Building energy operation	£930
Owned outright	Cavity wall insulation	£410
Owned with mortgage	Cavity wall insulation	£410
Shared ownership	Cavity wall insulation	£370
District owned	Cavity wall insulation	£370
Social housing assoc.	Cavity wall insulation	£370
Private rented	Cavity wall insulation	£380
Owned outright	Solid wall insulation	£11,750
Owned with mortgage	Solid wall insulation	£11,750
Shared ownership	Solid wall insulation	£11,750
District owned	Solid wall insulation	£11,750
Social housing assoc.	Solid wall insulation	£11,750
Private rented	Solid wall insulation	£11,750
Owned outright	Domestic loft insulation	£300
Owned with mortgage	Domestic loft insulation	£300
Shared ownership	Domestic loft insulation	£290
District owned	Domestic loft insulation	£290
Social housing assoc.	Domestic loft insulation	£290
Private rented	Domestic loft insulation	£290

[27] Publicly available cost data from EST is provided as UK averages. We recognise that in some instances, due to variations in regulations and supply chains, costs are likely to be higher in Northern Ireland. As such, we recommend that regional variations are considered in advance of policy implementation.

Owned outright	Domestic floor insulation	£1,580
Owned with mortgage	Domestic floor insulation	£1,580
Shared ownership	Domestic floor insulation	£1,580
District owned	Domestic floor insulation	£1,580
Social housing assoc.	Domestic floor insulation	£1,580
Private rented	Domestic floor insulation	£1,580
Owned outright	Domestic windows - triple glazing	£3,060
Owned with mortgage	Domestic windows - triple glazing	£2,950
Shared ownership	Domestic windows - triple glazing	£2,600
District owned	Domestic windows - triple glazing	£2,550
Social housing assoc.	Domestic windows - triple glazing	£2,580
Private rented	Domestic windows - triple glazing	£2,640
Owned outright	Low temperature heating system	£4,810
Owned with mortgage	Low temperature heating system	£4,780
Shared ownership	Low temperature heating system	£4,450
District owned	Low temperature heating system	£4,410
Social housing assoc.	Low temperature heating system	£4,440
Private rented	Low temperature heating system	£4,480
Owned outright	Lighting efficiency	£100
Owned with mortgage	Lighting efficiency	£100
Shared ownership	Lighting efficiency	£90
District owned	Lighting efficiency	£90
Social housing assoc.	Lighting efficiency	£90
Private rented	Lighting efficiency	£100

Table 40: Costs of interventions for non-domestic buildings

Building tenure	Intervention	Cost per intervention
Education	DHW saving measures	£360
Health	DHW saving measures	£560
Government	DHW saving measures	£30
SME owned	DHW saving measures	£70
SME rented	DHW saving measures	£50
Large enterprise owned	DHW saving measures	£120
Large enterprise rented	DHW saving measures	£70
Education	Building energy operation	£3,100
Health	Building energy operation	£2,390
Government	Building energy operation	£260

SME owned	Building energy operation	£1,920
SME rented	Building energy operation	£1,870
Large enterprise owned	Building energy operation	£3,580
Large enterprise rented	Building energy operation	£3,830
Education	Cavity wall insulation	£2,110
Health	Cavity wall insulation	£520
Government	Cavity wall insulation	£140
SME owned	Cavity wall insulation	£1,540
SME rented	Cavity wall insulation	£1,250
Large enterprise owned	Cavity wall insulation	£1,300
Large enterprise rented	Cavity wall insulation	£1,080
Education	Solid wall insulation	£12,670
Health	Solid wall insulation	£3,100
Government	Solid wall insulation	£800
SME owned	Solid wall insulation	£9,210
SME rented	Solid wall insulation	£7,500
Large enterprise owned	Solid wall insulation	£7,730
Large enterprise rented	Solid wall insulation	£6,480
Education	Non-domestic high efficiency glazing solar shading	£12,060
Health	Non-domestic high efficiency glazing solar shading	£2,960
Government	Non-domestic high efficiency glazing solar shading	£800
SME owned	Non-domestic high efficiency glazing solar shading	£8,820
SME rented	Non-domestic high efficiency glazing solar shading	£7,150
Large enterprise owned	Non-domestic high efficiency glazing solar shading	£7,400
Large enterprise rented	Non-domestic high efficiency glazing solar shading	£6,170
Education	Low temperature heating system	£21,500
Health	Low temperature heating system	£10,090
Government	Low temperature heating system	£590
SME owned	Low temperature heating system	£3,550
SME rented	Low temperature heating system	£3,660
Large enterprise owned	Low temperature heating system	£3,620
Large enterprise rented	Low temperature heating system	£3,530
Education	Lighting efficiency	£1,130
Health	Lighting efficiency	£370
Government	Lighting efficiency	£130
SME owned	Lighting efficiency	£1,180
SME rented	Lighting efficiency	£1,120
Large enterprise owned	Lighting efficiency	£3,010
Large enterprise rented	Lighting efficiency	£3,400

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