






RURAL ENGLAND

NETWORKING / RESEARCH / LEARNING

DECARBONISING HEATING AND HOT WATER IN RURAL OFF-GAS GRID PROPERTIES:

RESEARCH ON THE IMPACTS ON RURAL HOMES AND BUSINESSES AND POLICY IMPLICATIONS

September 2023

ABOUT US

Rural England CIC is a not for dividend organisation with any surpluses re-invested in meeting the Company's Objectives. Its mission is to build the strength and resilience of rural England by helping to inform and engender better rural policy making. It does this by encouraging informed debate, providing independent research and evidence, supporting informed information exchange, and building a network that draws together all those who seek to sustain and improve the social, economic, and environmental well-being of rural England. The prime focus of the company is on research to further the understanding of issues affecting people, businesses, and communities in rural areas of England that will provide objective evidence to inform and influence policy and policymakers.

Background and context

Decarbonising homes and commercial premises is a crucial element of the Government's Net Zero Strategy (including its interim/2030 target).

A significant challenge within that, is how best to support the decarbonisation of off gas grid properties through a just transition. Off gas grid properties form half of the housing stock and thousands of business premises in rural settlements.

This project seeks to inform the debate on achieving that just transition.

The Government issued two consultation papers seeking comments by 12th January 2022 on the subject of "Phasing out the installation of fossil fuel heating systems in (1) homes and (2) businesses and public buildings off the gas grid.

The consultations states that there are around 1.1m fossil fuel heated homes in England which are not connected to the gas grid. This breaks down to 78% using heating oil, 13% using liquified petroleum gas or LPG, and 9% using coal.

The consultations also states:

"Off the gas grid there is no strategic hydrogen option. Electrification of heat is the one pathway to net zero proven to work at scale across a broad spectrum of homes, and other low-carbon heating solutions are available in the small number of homes where heat cannot be decarbonised through electrification.

"In the Clean Growth Strategy (2017) the Government committed to 'phase out the installation of high-carbon fossil fuel heating in new and existing homes currently off the gas grid during the 2020s, starting with new homes. This was followed by a call for evidence in 2018 seeking views on the future policy framework for decarbonising heat in buildings – which found that a consistent, long-term policy framework, backed by regulation, will be needed to fully decarbonise heat. This consultation seeks views on the government's proposals to decarbonise heat in homes off the gas grid through targeted regulations, including:

1. *An end to the installation of fossil fuel heating in homes off the gas grid from 2026.*
2. *A 'heat pump first' approach to replacement heating systems from 2026; and*
3. *Requiring high performing replacement heating systems where heat pumps cannot reasonably practicably be installed, we are also considering whether it is appropriate to end the use of fossil fuel heating in all homes off the gas grid, potentially by the late-2030s"*

Numerous members of Rural England's Stakeholder Group submitted responses to the consultations. Underlying many comments is a sense that heat pumps will be a good solution for many properties but may not be for very many rural off gas grid properties.

16 months on the Government has yet to respond to the Consultations.

While the principle of requiring low carbon heat and energy to be fitted within the 'boiler replacement cycle' is clear there are several aspects of the proposals that may differentially affect those living in certain locations and circumstances.

Some considerations for rural areas have been highlighted by many representing the rural sector including:

- The Government's Heat and Buildings Strategy acknowledges that.

  "Heat pumps may not be the most suitable technology for all buildings, for example where there is little outside space or separation distance from neighbouring properties, or where the building has very poor thermal efficiency that cannot be addressed cost-effectively. However, BEIS analysis suggests that around 80% of fossil fuel heated off-gas-grid homes in England have sufficient energy efficiency and internal fuse limit electrical connections to accommodate a low temperature heat pump system".

- The fact that a property has an electrical connection to accommodate a low temperature heat pump system does not translate into a statement that the property is “heat pump ready”. There are many other aspects to consider. There are certainly different situations with rural property architypes (e.g., may be older, less easy (and more expensive) to insulate, or less suitable for heat pumps).
- A replacement (oil/gas) boiler ban is proposed from 2026 in off-grid homes and 2024 for larger (>1000m2) off-grid businesses. As most off-grid premises are in rural areas this may translate into higher replacement heating costs for rural homes and businesses compared to urban areas, where an on-grid replacement boiler ban won’t occur until about 2035.
- According to the consultation, air source heat pumps cost on average £12,000 per rural home to fit and while cost reductions are expected in time (achieving parity with gas boiler replacement costs) if off-grid rural areas are to decarbonise first they will not enjoy full benefit of any cost reduction in heat pumps; and
- Electrification may not always be the only (or most appropriate) way to decarbonise some buildings and there will be situations where rural off-grid properties may benefit from a mixed technology approach that might include biofuels such as BioLPG and bioliquids and will also broaden the range of cost-effective low carbon solutions.

Wider Rural Context

Before looking at the specific issues of the decarbonisation of off gas grid rural properties it is worth noting some of the wider societal context of rural communities.

- The population of rural England is older than the national average and is ageing faster. Analysis of the 2021 census shows a 27% increase in predominantly rural areas of the 65 years and over age group population compared to 2011. This age group now accounts for 24% of predominantly rural total population (urban areas 16%) an increase from 19% in 2011. For the 85 and over age group the population has increased in predominantly rural areas by 22% since 2011 (16% for predominantly urban areas). This age group is 3% of total predominantly rural population compared to 2% for predominantly urban areas. In 2018 The number of over 85-year-olds was projected to increase by 117.9% by 2041 in predominantly rural areas (92.7% for predominantly urban). Workplace based earnings are some 15% lower in rural areas (£22,700 in 2020) compared to England (£26,100 in 2020).
- The cost of living in rural areas is higher than the rest of the country.
- There are still broadband and mobile phone connectivity issues in many rural areas (see CMA report mentioned later for the context of this point).
- Many off-grid properties are not uniform in design and are idiosyncratic in character meaning efforts to standardise heat pump installations may be less effective at reducing install costs. They are often a lot older and tend to be poorly insulated.

Purpose of Research Commissioned

Rural England C.I.C commissioned independent research from Kovia Consulting to consider the implication of the proposals to phase out the installation of fossil fuel heating systems in rural homes and business premises off the gas grid.

The research was aimed to test some of the points referred to above through a range of case studies of real rural situations.

The Kovia Consulting Report is attached as an Appendix to this report. Almost twenty case studies were developed examining occupier perceptions and the 'reality' of decarbonisation of rural off-grid properties. The case studies highlight several points:

- **Broadly, none of the properties included in the eight domestic case studies that did not have an air source heat pump fitted were immediately "heat pump ready" with seven requiring significant work (mainly insulation) to ensure that air source heat pumps would be cost effective. While this small sample is illustrative rather than representative. it was designed to examine a variety of not untypical rural situations and thus highlights the range of problems and challenges that will be encountered by many rural households and businesses, as they seek to decarbonise.**
- **Heating decarbonisation tended to come forward on properties where the occupiers were able to access some funding toward elements or where they were renovating properties and could afford to do so.**
- **Only a limited number of occupiers were contemplating decarbonisation – energy efficiency and reducing bills were the greater drivers - and none were aware of the government's off-grid boiler ban policy proposals.**
- **Homes that were contemplating or had heat pumps installed were facing more than the cost of installation to attain efficient systems and while there were some helpful reported benefits many were not able or keen to install heat pumps.**
- **Alternative low carbon technologies are not currently recommended in official appraisal software (SAP), such as retaining existing boiler and switching to biofuels such as BioLPG and bioliquids, which could provide low carbon solutions that would result in less cost and disruption to many with existing systems.**
- **Business occupiers were keen to decarbonise yet lacked an incentive to decarbonise given the findings of non-domestic energy assessment; More financial help and guidance will be needed to help the majority achieve efficient decarbonised off-gas grid solutions to their heating and hot water needs; and**
- **There were a wide variety of property types surveyed each with its own somewhat unique circumstances. A one-size-fits-all policy response may not be the most effective approach.**

Wider findings

Inadvertently, the research has also, in effect undertaken:

1. **a snapshot of progress of households and businesses towards decarbonisation; and**
2. **a qualitative evaluation of the current energy performance certificates (EPCS) rating system and its ability to help meet policy ambition for decarbonisation of off-grid.**

Despite the off-gas grid focus, it is thought the findings in this respect are also relevant to urban and sub-urban settings too:

- **The work illustrates the range of failures across policy and other interventions to bring forward decarbonised and energy efficient properties.**
- **Those that were eligible for funding took advantage of technology offered occasionally at the expense of a 'common-sense' whole building approach. This resulted in significant disruption to occupants and inefficient buildings.**
- **Many examples of poor-quality work with contractors 'learning on the job' how to install renewables or heat pumps; and**
- **Inconsistencies and an altogether out of date appraisal framework (RdSAP) made many inappropriate recommendations and in many cases (there were very few instances where heat pumps were recommended with the types of property archetypes encountered) "locked in" disincentives for occupiers to act or comply with proposed off-grid boiler upgrade policy."**

RECENT NATIONAL REPORTS

In recent months the following national reports have been issued which put some further context to discussions about heating rural housing stock. They are:

1. Annual Fuel Poverty Statistics (February 2023)
2. Competition and Markets Authority (CMA) Report on "protecting people in the move to greener, energy efficient homes (May 2023)
3. English Housing Survey: local authority housing stock condition modelling (June 2023)
4. Citizens Advice Energy Demand
5. National Energy Action, Making heat pumps work for fuel-poor households

1 Annual Fuel Poverty Statistics (February 2023)

These statistics for the year 2022 show that households living in rural areas have the highest fuel poverty rate of 15.9% compared to urban areas having the overall median rate of 13.4%. For rural areas *the fuel poverty gap (the additional income which would be needed to bring a household to the point of not being fuel poor) in 2020 was £501 with urban areas at around £200.* **In 2022, these figures are astronomical for rural areas with the fuel poverty gap sitting at £956 compared to the lowest fuel poverty gap in London at £223.**

In addition, the statistics confirm the figures for off gas grid housing with 52.6% of rural properties being off the gas grid compared to just 9.8% of urban properties.

2 Competition and Markets Authority (CMA) Report on "protecting people in the move to greener, energy efficient homes (May 2023)

Whilst no specifically rural issues are raised it does almost certainly mean that the issues of concern raised by the CMA will resonate in rural areas – especially if they are required to replace a boiler (in the case of breakdown) with a non-fossil fuel heating system after 2026.

The report focused on three key themes and sought to identify any existing problems, as well as problems that could arise as the sector develops. While the CMA found evidence of benefits to consumers, it also identified concerns in each of these broad themes:

- **Theme one: people's experience of buying green heating and insulation products** – the CMA found difficulties for people at various stages, particularly early on when it can be hard to find the right information to inform important decisions and to identify trustworthy businesses.
- **Theme two: business practices in the sector** – the CMA identified concerns that some businesses are making misleading claims about products, and some are engaging in greenwashing (i.e., false, or overstated claims about the product's environmental credentials), as well as concerns about limited transparency of price information.
- **Theme three: the landscape of standards bodies overseeing quality and consumer protection standards for member businesses** – the CMA found that the landscape is complex and can be confusing for people to navigate, which can mean that they miss out on the benefits. It also identified emerging gaps in protection for 'able to pay' consumers (who self-fund their purchase and are not eligible for government funding).

The CMA concludes that in the face of these difficulties, there is a significant risk that people either are put off from buying green heating and insulation products or end up making poor decisions if they do go ahead.

The CMA also comments that “Some groups are likely to face additional challenges which might further limit their ability to access or make informed decisions about green heating and insulation products. It is essential that such groups receive any additional support they may need and are not left behind in the move to more energy efficient homes. For example: **(a) People who are ‘digitally disadvantaged’ (around 1 in 20 UK adults) can struggle to access information, as much of it is online.** (b) Information presented to disabled consumers may not be sufficiently accessible and the installation process might not account for their needs (such as the impact of disruption to energy supply). Although the CMA focused on the early challenges people face, given the need to build consumer confidence in the sector, it also found some issues later in the consumer journey. Linked to the information gaps, it can be difficult to find credible, trusted installer businesses – which limits people’s ability to shop around to get the best deal (34% of consumer respondents who bought a product had not shopped around).”

3 English Housing Survey: local authority housing stock condition modelling (June 2023)

For a dwelling to be considered ‘decent’ under the Decent Homes Standard, it must:

- meet the statutory minimum standard for housing (the Housing Health and Safety Rating System, since April 2006), homes which contain a Category 1 hazard under the HHSRS are considered non-decent.
- provide a reasonable degree of thermal comfort.
- be in a reasonable state of repair.
- have reasonably modern facilities and services.

The figures show that 19.8% of all dwelling stock in Predominantly Rural authority areas are non-decent. That is 1,021,989 dwellings. Compared with 15.7% for Predominantly Urban local authorities (2,377,645 dwellings).

The following Table provides details by type of occupation:

	Proportion non-Decent			
	Owner occupied	**Private rented**	**Social**	**All Rented**
Predominantly Rural	19.3	29.3	14.1	21.2
Predominantly Urban	15.3	21.9	11.7	16.4
Urban with Significant Rural	16.2	23.9	10.9	16.6

Of the top 10 local authorities with the highest proportion of non-decent dwellings, 7 are Mainly Rural, one is Largely Rural and two are Urban with Significant Rural.

4 Demand net zero Citizens Advice (May 2023)

Homeowner interest in retrofit measures is low. For those who are interested, only a minority can afford measures without borrowing. Our findings suggest that while 1 in 2 homeowners can afford cheaper retrofit measures without additional borrowing, this falls to only 16% for heat pumps. For homeowners unable to afford upfront costs, borrowing is not seen as an attractive option. Fewer than 1 in 5 homeowners are willing to borrow either through a mortgage or unsecured loan to fund improvements.

5 National Energy Action, Making heat pumps work for fuel-poor households.

The insulation standard of some homes means that a heat pump system may not be suitably effective at keeping the home comfortably warm in winter or when it is cold outside or may unnecessarily increase the costs of doing so beyond what is affordable for the household.

Make sure the home is suitably insulated before you start, and that you can access funding for improving the energy efficiency of the home before installing a heat pump.

RECENT DEBATE IN THE HOUSE OF COMMONS

There was a debate on Tuesday 13 June led by Sir Bill Wiggins MP (North Herefordshire) who said at the end of the debate:

"*To conclude, I commend the Government on their net zero policy and on our environmental agenda. We must pursue a more flexible, cost-effective, and practical approach to heating rural homes that considers the unique circumstances of these areas. The Government's 2026 boiler ban is a misguided policy that fails to consider the practical implications and financial hardships that it would impose on people living in rural communities. We must ensure that the voice of rural homeowners is heard, and that their concerns are addressed. I urge the Government to re-evaluate their strategy, drop the ban, and develop a plan that prioritises practicality, affordability, and choice for rural homeowners, and ensures that those living in rural homes are not unfairly disadvantaged because of where they live.*"

In response to the debate The Rt Hon Amanda Solloway MP (the Parliamentary Under-Secretary of State for Energy Security and Net Zero) said:

"The Government have a commitment to transition to clean heat for the future. My hon. Friend asked me about a date, which I am unable to give at this stage, but I will look into that consultation and get back to him as soon as I can.

I also take this opportunity to reassure my hon. Friend that no one will be required to install an unsuitable technology in their home or business. Heat pumps will not work everywhere—some off-grid properties are simply too poorly insulated or have certain characteristics that would make installing the technology challenging. We are therefore looking closely at the potential role of low-carbon heating solutions, such as high-temperature heat pumps, hybrid heat pumps, solid biomass, or renewable liquid fuels.

We will continue to work with industry stakeholders to build further evidence that will allow us to evaluate what roles these fuels may play in heat, especially where heat pumps cannot be used." … "I assure my hon. Friend that we are acting and will continue to act to ensure that the transition to clean heat is smooth, fair and affordable for rural off-grid households and businesses."

RURAL ENGLAND C.I.C's COMMENTS TO INFORM THE POLICY DEBATE

1 The lack of information from the Government about its policy intentions for phasing out the installation of fossil fuel heating systems in (1) homes and (2) businesses and public buildings off the gas grid is causing much anxiety for rural representatives, and those who do know of the proposals. The lack of information may well be contributing to ill-informed choices. See the CMA report referred to above.

Polling of rural consumers by Liquid Gas UK in 2021 showcased significant concerns about the limited choice of heat pumps as alternatives to existing oil and LPG boilers:

- 79% were concerned about the upfront cost.
- 75% were concerned about the ongoing running cost.
- 59% were concerned about the upheaval or disruption of installation.
- 59% were concerned about the availability of consistent and reliable heat.
- 41% were concerned about ease of use.
- 33% were concerned about the impact on the exterior of their home.

Heat pumps will be a good solution for many properties, including in rural areas but may not appropriate for very many rural off gas grid properties.

2 The Kovia work is illustrative and demonstrates the flaws in the assumptions that this transformation will be easy, efficient and will result in a good solution for rural homeowners and businesses. The case studies were not selected to pick 'problem' cases: the range of problems illustrated came from a selection of different locations, house types, etc. so that it could avoid obvious bias in the sample.

3 In response to a Westminster Hall debate on 16th June 2022 the then Minister for Energy, Clean Growth and Climate Change, Greg Hands MP, made several important points to note relating to the issues put forward. He said:

"no one will be required to install an unsuitable technology in their home or business. We know well that heat pumps will not work everywhere, at least not with the current technology. Some off-grid properties are simply too poorly insulated or have certain characteristics that would make installing the technology impossible. We will take care to ensure that that group of hard-to-treat properties will have access to suitable alternatives, such as high-temperature heat pumps, solid biomass and so on."

"My right hon. Friend asked me to reconsider the 2026 deadline. Equally, the pace at which we can make heat pumps become affordable will guide our decisions on the right time to introduce regulation and the other actions needed to make a fair transition."

"On his questions about hybrids and biofuels, along with those from my hon. Friend the Member for Buckingham, we would like to see those fuels become another solution, particularly for off-grid properties that cannot use a heat pump. We are working closely with industry to build the evidence that will inform the biomass strategy mentioned by my hon. Friend, due to launch later in 2022. The strategy will review the amount of sustainable biomass likely to be available to the UK and set out how this can be best used across the economy to achieve our net zero targets."

4 Despite being almost 12 months on from the above statement all there is to go on at present are the policy propositions set out in the consultation which closed in January 2022. The Biomass Strategy referred to above has still not yet been published.

The principal issues of concern currently appear to be:

- Moving rural areas off the gas grid network to non-fossil fuel heating systems (in the case of irreparable boiler breakdown – therefore usually a distressed purchase in winter) too soon – with the proposal to do so much sooner than for on gas grid areas.
- As reflected through the Kovia case studies, the apparent 'one-size-fits-all' approach to electric heat pumps and the lack of willingness to include other alternative low carbon fuel sources.
- The Standard Assessment Procedure (SAP) methodology – and, in particular, the RdSAP model (a reduced form of SAP) – which is used to generate recommendations for Energy Performance Certificates and used to calculate

a homes' energy performance needs to reflect a more diverse range of options. It favours heat pumps where they may not be the best option (or indeed, practical) for many rural properties.

- Off-grid properties face particular challenges from the EPC methodology to measure energy efficiency. This is because the energy efficiency metric takes into account both the fabric efficiency of the building and also the higher costs of heating oil compared to natural gas (something which is no longer as relevant as it may have been due to recent increases in the cost of gas). The methodology essentially is based around energy cost square metre of property, rather than true energy efficiency. As such off-grid households with more expensive heating systems -be they renewable or fossil fuel based - end up with the worst EPC rating.
- The lack of recognition of the diverse rural housing stock (as reflected through the Kovia case studies) which makes heating and treating them more expensive and works more disruptive.
- There appears to be a "baked in assumption" within the heat and building strategy that the price of heat pumps will dramatically reduce by 2030 - an assumption which critics of the policy argue the government is over reliant on. Furthermore, many older rural houses off the gas grid are technically unsuitable for the energy efficiency measures which are required in order for heat pumps to work.

5 Having regard to the report of Kovia Consulting and our own desktop research of the issues concerned, Rural England C.I.C consider the following should be considered for the development of future policy:

1. Drop the proposed 2026 'enforced early adoption' requirement for off gas grid homes. It is clearly inappropriate to impose this requirement until rural electricity supply networks are improved and both insulation systems and sustainable energy alternatives to heat pumps are available at cost levels for both installation and operation that are reasonable in comparison to national averages and existing heating systems.

   It seems probable that the current proposals could translate into higher replacement heating costs for rural homes and businesses compared to urban, where there is no comparable on-gas grid replacement boiler ban date, although 2035 has been suggested. This is a significant issue, especially given the lower wages in rural areas and the higher cost of living.

   Evidence shows that heat pumps cost on average £12,000 per rural home to fit – with many rural homes costing very much more – and according to an independent report, the Government's ambition for heat pumps to reach cost parity with gas boilers by 2030 is unrealistic. Delta EE's1 analysis suggests that even in their optimistic scenario, "the marginal cost of a heat pump compared to a gas boiler [would reduce] to around £4,000. It is therefore not enough in itself to bring down the upfront costs of a heat pump in line with a gas boiler".[1]

[1] www.delta-ee.com/press-release/heat-pump-costs-projected-to-fall-by-40/

While cost reductions are expected over time, if off-grid rural areas are required to decarbonise first, they will not enjoy the full benefit of any cost reduction in heat pumps.

2. **It is important that Ofgem carry out a full review of resilience requirements with the Distribution Network Operators.** This would enable issues of rural resilience and capacity to be addressed ahead of their next five-year business planning cycle, 2023-28, and ensure resources are available to upgrade the rural network. [It should be noted that the Energy Security Bill will add new net zero obligations on Ofcom]

   It should be noted that in a keynote speech on 6th of June 2023 the Environment Secretary said that the government plans to support electricity infrastructure in rural areas, making sure it keeps up with the changing needs of customers for example, to support the electrification of heating and EV charging, by publishing further plans to accelerate electricity network Connexions. The government appears to accept there is an issue but as yet there is no change to the proposed 2026 date for the "banning" of replacement fossil fuel boilers in the case of boiler breakdown in off gas grid areas.

3. **Adopt a mixed technology approach to the decarbonisation of rural, off-grid properties that allows consumers a choice of how best to decarbonise heating their homes and businesses.**

   Whilst we agree heat pumps may well be a good solution for many properties in rural England, electrification will not always be the only – or best way - to decarbonise and there will be situations where rural off-grid properties may benefit from a mixed technology approach that might include bio and recycled carbon fuels such as renewable liquid gases (BioLPG, rDME), wood pellets and bioliquids (e.g. HVO) and will also broaden the range of cost-effective low carbon heating solutions.

   Archetype analysis by Ecuity in 2021 found that for properties built before 1945, the lowest capital heating cost system would be a bioLPG boiler. To achieve equivalent carbon savings with any other technology, the upfront costs are at least six times greater. For the same property archetype, the installation and requisite retrofit of an air source heat pump would be £29,690, with annual running costs of £1,023.

   There is strong evidence that many smaller rural homes will not be suitable for re-installation (at considerable cost, even where it is possible) of radiators and pipework that can operate with lower temperature heat pumps. For these properties, there appears to be a clear case for considering a mixed technology approach, with consumers allowed the flexibility to install a low carbon system that meets their individual situation, with renewable liquid gases offering a 'drop in' solution, making it more cost-efficient and less disruptive to the household. Currently, facing these costs, is a significant barrier for rural properties achieving net zero.

There is concern that an unintended consequence will be old, dirty, oil-fired, boilers being 'kept running,' replaced ahead of the proposed 2026 'boiler ban' or adapted. This will lead to outcomes that are diametrically opposed to the overall policy objectives.

Many commentators have said that while an eventual transition to heat pumps maybe the desired outcome, the current all or nothing policy approach of the government, through the 2026 end date for the installation of fossil fuel heating as well as the 'heat pump first' approach, places an unfair and disproportionate burden on off-grid properties. A significant issue with the approach being proposed is that the incentive schemes attached to it do not give a variety of cost-effective choices to consumers as to what heating technology they can choose.

4. **All the evidence suggests that there is a need to put in place a financial support package for at least a decade, tailored specifically to the circumstances of off-gas grid homes. The support package should have the objective of enabling these homes to address whole house energy efficiency and transfer to sustainable energy alternatives, (including insulation and up-rated electricity supply to the premises) at a like-for-like cost with gas or oil boilers.**

   Alternatively, a more broadly specified 'net-zero ready' funding programme could help meet transition costs on a more flexible basis including alternatives to heat pumps where appropriate.

5. **There is a clear need for guidance and support to be put in place for off gas grid residents** that will enable them to understand the 'road map' towards low carbon and decarbonised heating for reviewing whole house solutions for homes with their specific characteristics (e.g., heritage status, construction type, quality of electricity supply, options in addition to heat pumps etc.). The need for such guidance is clearly demonstrated by the Kovia case studies.

6 It is apparent that there is an increasing need for both locally provided and accessible **training and the development of more people to be able to provide appropriate installation and maintenance services in all areas.** Most off-gas households are in rural areas, often very remote. The availability of skilled tradesmen willing to travel has often been a cause for concern in such areas.

Overall, Rural England C.I.C. consider that pushing ahead with a uniform assumption that heat pumps are the best option for all rural off-grid situations is incorrect, and likely to lead to:

- significant additional cost for many of the non-standard consumers involved.
- significant lack of the efficiency benefits claimed, or at least a much longer timespan before these benefits could be realised and thus a risk of unhelpful 'lock in' to sub-optimal technologies, in the medium term.

- significant missed opportunities for swifter, cheaper and more adaptable strategies for non-standard houses and family/business situations that could be enabled by a fabric-first approach and acceptance of a more heterogeneous set of decarbonisation options embracing a range of alternative fuels.
- a huge, missed opportunity to use this transition strategy as a device to enable and empower local communities to own the decarbonisation agenda themselves, offering them practical and independent information, and accessible/affordable financial support, to build resilient systems that suit their own situations. There is considerable diverse expertise already available across the sector and from existing research and evidence into what works, which could be better mobilised to address this challenge.

RURAL ENGLAND C.I.C. hopes that these thoughts and the analysis in this research paper will help inform the on-going debate about achieving a just transition to net zero across the rural areas of England.

APPENDIX

Decarbonising rural off gas grid properties

Case study research

For

RURAL ENGLAND
NETWORKING / RESEARCH / LEARNING

By

Kovia CONSULTING

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Legal statement

About Kovia

Kovia is a Cornish word meaning "protect" and reflects the core value of our business to protect human health, communities, and the natural environment. The Kovia group of companies includes Kovia Ltd and Kovia Environmental Services Ltd. Kovia Ltd is an established statutory compliance inspection, testing and training provider specialising in asbestos, fire, legionella and energy efficiency services. Kovia Environmental Services Ltd specialises in all aspects of asbestos remediation and removal, demolition, maintenance and re-instatement works.

Kovia Consulting Ltd provides advice and research that draws on a deep understanding of several technical disciplines from earth, environmental and climate science; finance, economics and business management; sustainability; social research and development studies; education; engineering and construction.

Image front cover by Kovia Consulting Ltd.

Contents

1 Introduction

This section provides an overview of this document including the purpose, background, guidance and methods used.

1.1 Purpose of research commissioned and the approach taken

1.1.1 Rural England C.I.C commissioned independent research from Kovia Consulting to consider the implication of the proposals to phase out the installation of fossil fuel heating systems in rural homes and business premises off the gas grid.

1.1.2 The research was aimed to test some of the implications through a range of case studies of real rural situations. It is important to note that the case studies from this report were selected randomly and were not selected because they show overly positive or negative situation. The opinions of occupants are described in full and in many cases verbatim.

1.1.3 The case studies are from examples across the southwest of England yet are considered representative of other rural areas. It is the view of Kovia Consulting that another twenty or so case studies selected randomly would raise the same range of issues and sentiment.

1.1.4 The case studies examine situations where either i) occupiers were presented with a report describing the work required to improve energy efficiency and decarbonise. Occupier's pre-conceptions and reaction to proposals were investigated; or, ii) where works had previously been undertaken to establish the impacts on occupiers and how they measured against their expectations.

1.1.5 In the final part of each case study, there is a short statement of potential impact on occupiers considering the hypothetical situation that the replacement (gas) boiler ban is in-acted as currently proposed (from 2026 in off grid homes and 2024 for some off grid businesses). There is an element of subjectivity in this final part of the case study where the likely impact is inferred from the information available and occupier's comments.

1.2 The property surveys undertaken

1.2.1 Surveys, undertaken by qualified energy assessors occurred from July 2022 until December 2022 and prices and survey recommendations reflect those prevailing in that period. Interviews were undertaken when the reports were available at the end of 2022 and up until April 2023. We have refrained from providing personal details and occupants responses are not attributed. Energy performance certificates are available but not provided to ensure anonymity.

1.2.2 Properties were separately surveyed by energy assessors. Occupiers were contacted by a separate experienced researcher (the same researcher in each case to ensure consistency) and firstly asked, given an overview of the aims if they would be happy to provide a response. An overview of specific research questions used to develop the case studies was also provided. Interviews were mainly by telephone and some face to face but covering the same questions.

1.2.3 Broadly three quarters of those contacted for the interviews responded and all consented to be interviewed. Those that did not respond were busy and / or at work despite some surveys taken out work hours (evening and weekend). In all cases the questions were 'open' and the order depended on responses provided. It was agreed that the case studies would be anonymised and as a result personal details and addresses have not been reported. Interviewees were also made aware and that they would be happy if conversation could be recorded to capture quotes. The interviews were undertaken adhering to ethical issues of confidentiality and informed consent.

1.3 Limitations

1.3.1 This report is based on the information available from assessments and interviews undertaken. It had been hoped to provide a comprehensive set of economic costs and benefits for each property. It was not possible to fully quantify and value many of these costs and benefits and those that were available are stated. We would have liked to have included more commercial properties, but many were apprehensive about being involved (some refused to participate after the survey had been undertaken) as the deadline for minimum energy efficiency standards (MEES) was introduced on 1st April 2023. This introduced a legal requirement for minimum ratings when leased (requirement for commercial buildings to have a rating of at least an E before a new lease or renewal lease was granted).

1.4 Sections of report

1.4.1 The next section provides the key findings of the research followed by sections describing the case studies of domestic and commercial premises.

2 Key findings

The key findings of the research.

2.1 Main study objectives

2.1.1 Almost twenty case studies have been developed examining occupier perceptions and the 'reality' of decarbonisation of rural off-grid properties. Tables follow (Table 2.1 and 2.2) and provide a summary of the main findings from this work. The case studies highlight a number of points:

- Decarbonisation tended to come forward on properties where the occupiers were able to access some funding toward elements or where they were renovating properties and could afford to do so;
- Broadly, none of the properties included in the eight domestic case studies that did not have an air source heat pump fitted were immediately "heat pump ready" with seven requiring significant work (mainly insulation) to ensure that air source heat pumps would be cost effective. While this is 'typical' it is not reasonable to suggest that this is representative of all rural properties given the size of sample and way case studies were chosen;
- Only a limited number of occupiers were contemplating decarbonisation – energy efficiency was the greater driver - and none were aware of off-grid boiler upgrade policy recommendations;
- Clearly homes that were contemplating or had heat pumps installed were facing more than the cost of installation to attain efficient systems and while there were some helpful reported benefits many were not able or keen to have heat pumps;
- In some cases alternative technologies are not recommended in appraisal software, such as replacement with biofuels such as BioLPG and bioliquids could provide low carbon solution that would result in less cost and disruption to many with existing systems;
- Business occupiers were keen to decarbonise yet lacked an incentive to decarbonise given the findings of non-domestic energy assessment; and
- More financial help and guidance will be needed to help the majority achieve efficient decarbonised off grid solutions to their heating and hot water needs.

2.2 Wider findings

2.2.1 Inadvertently, the research has also, in effect undertaken:

i. a snapshot of progress of households and businesses towards decarbonisation; and

ii. a qualitative evaluation of current energy performance rating system and ability to help meet policy ambition for decarbonisation of off-grid.

2.2.2 It is suspected that the findings in this respect are relevant to urban and sub-urban settings:

- The work illustrates the range of failures across policy and other interventions to bring forward decarbonised and energy efficient properties;
- Those that were eligible for funding took advantage of technology offered occasionally at the expense of a common-sense whole building approach. This resulted in significant disruption to occupants and many inefficient buildings;
- Many examples of poor-quality work and contractors learning on the job through their mistakes how to install renewable or heat pumps; and
- Inconsistencies and an altogether out of date appraisal framework (RdSAP) made many inappropriate recommendations and in many cases (there were very few instances where heat pumps were recommended with the types of typologies encountered) “locked in” disincentives for occupiers to act or comply with proposed off-grid boiler upgrade policy.

Table 2.1 Residential (All Domestic Energy Reports)

Location	Property type	Total area (m^2)	Main heating fuel	Building emission rate ($kgCO_2$ / m^2 per year)	Primary energy use (KWh / m^2 per year	Assessed energy rating	Assessed CO_2 rating	Assessed by energy calculation tool to be suitable for heat pump.	Will need to consider replacement boiler ban post 2026	Might benefit from a mix approach to decarbonisation e.g., biofuels or broader	Occupier believes costs likely to be greater than benefits moving to low carbon	Comment
A	Stone built c.1910 Detached	274	LPG (tank)	49.34	225	F 25 (Potential D 67)	E 43 (potential C 77)	No	Yes	Yes	Yes	Significant costs to insulate and not considered practical given building aesthetic.
B	1950's end of terrace bungalow	73	Mains electric with solar PV	43.99	260	C 75 (Potential B 88)	E 50 (potential C 69)	No	No	No	N/A	Install followed grants available and cannot afford further upgrade.
C	1960s mid-terrace bungalow	45	Mains electric with solar PV	51.61	305	E 53 (Potential A 99)	C 60 (potential B 81)	No	No	No	Yes – interested when can save money	Electric heating inefficient even solar PV fitted.
D	Victorian end of terrace house	128	Had air source heat pump fitted	35.66	211	D 61 (Potential A 100)	D 65 (potential A 100)	N/A (fitted)	No	N/A	N/A	Heat pump not performed well and needs other actions to improve efficiency.
F	Pre-1900 stone barn	120	Oil	-	-	-	-	-	Yes	Yes	Yes	Very inefficient building and owner will not replace AGA
G	Victorian detached house	145	Had air source heat pump fitted	37.41	221	E 48 (Potential A 98)	E 54 (potential A 98)	No – but fitted by recommendation	No	No	No	Owner did not want to install wall insulation.
I	1960's end of terrace bungalow	116	Had air source heat pump fitted and solar PV	15.64	93	C 76 (Potential A 112)	C 78 (potential A 110)	No but fitted as grant available.	No	No	Yes, although very disruptive.	Glad of air quality benefit now no oil burner / heating. Only possible through grants
K	Pre-1900 stone farmhouse (Tenants)	231	Oil and solid fuel	49.03	186	E 53 (Potential B 89)	E 45 (potential B 81)	No.	Yes	Yes	No	Keen to decarbonise but assessment will not make landlord act in medium term.

Location	Property type	Total area (m^2)	Main heating fuel	Building emission rate ($kgCO_2$ / m^2 per year)	Primary energy use (KWh / m^2 per year	Assessed energy rating	Assessed CO_2 rating	Assessed by energy calculation tool to be suitable for heat pump.	Will need to consider replacement boiler ban post 2026	Might benefit from a mix approach to decarbonisation e.g., biofuels or broader	Occupier believes costs likely to be greater than benefits moving to low carbon	Comment
L	Stone and block mix of building ages end of terrace	84	Solid fuel and electric heating with solar PV	65.70	375	F 35 (Potential D 64)	E 41 (potential C 66)	No	No	No. LPG was deemed unsuitable given lack of garden space.	Heat pump offered but declined due to disruption, damage to building.	Electric heaters and uninsulated walls mean it is in-efficient.
M	1900 stone mid-terrace	46	Had air source heat pump fitted and uses solid fuel	89.14	437	E 41 (Potential B 88)	F 38 (potential B 83)	No but fitted as grant available.	No	No	Heat pump fitted as grant available. Occupier still can use fireplace and electric heaters/	Occupier did not believe wall insulation would help in stone cottage.
O.	Semi – detached, Victorian stone-built Grade II listed.	119	Had air source heat pump fitted	27.58	163	D 66 (Potential B 91)	C 69 (potential A 92)	Already fitted with old model upgraded recently.	No	No	Yes, especially health and wider community and heritage value benefits	Listing (Grade II) limits immediate extent of further improvements.
P	Pre-1900 detached cottage	100	Electric with portion from Solar PV	68.19	392	F 29 (Potential B 81)	F 37 (potential D 56)	No	No	No	Not yet – "only ½ a job done" and more to spend.	PV fitted as grant available may have benefited from different approach.
Q.	1980's detached bungalow	124	Had air source heat pump fitted	-5.78	-34	A 100 (Potential A 106)	A 100 (potential A 100)	N/A	No	N/A	Yes	Occupier able to afford heat pump and large solar PV array in well insulated recent bungalow.
R.	Pre 1900 detached stone cottage	103	Oil	70.22	269	E 44 (Potential B 84)	F 38 (potential C 78)	No	Yes	Yes	Yes	Significant costs to insulate and not considered practical given building aesthetic.

Source: Kovia

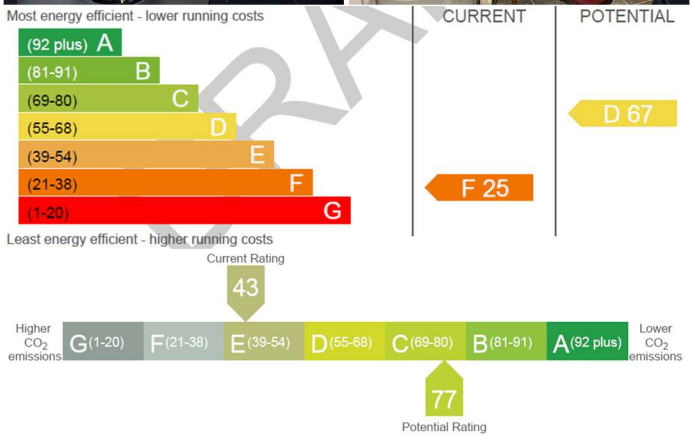
Table 2.2 Commercial (Non-domestic EPC and recommendations reports)

Location	Property type	Main heating fuel	Building environment	Total area (m^2)	Building emission rate ($kgCO_2$ / m^2 per year)	Primary energy use (KWh / m^2 per year	Assessed energy rating	Benchmarks	Assessed by energy calculation tool to be suitable for heat pump.	Will need to consider replacement boiler ban post 2026	Might benefit from a mix approach to decarbonisation e.g., biofuels or broader	Occupier believes costs likely to be greater than benefits moving to low carbon
E.	Retail/financial and professional services	Dual Fuel Appliances (Mineral + Wood)	Heating and natural ventilation	125	23.97	284	B 49	Newbuilt A 6 Typical of stock A 23	N/A	N/A	N/A	N/A
H.	Retail/financial and professional services	Grid supplied electricity	Heating and natural ventilation	24	56.56	585.85	C 74	Newbuilt A 5 Typical of stock A21	N/A	N/A	N/A	N/A
J.	Retail/financial and professional services	Grid supplied electricity	Heating and natural ventilation	61	28.77	301	B 47	Newbuilt A 1 Typical of stock A3	N/A	N/A	N/A	N/A
N.	Restaurants and Cafes/Drinking Establishments/Takeaways	LPG (bottle)	Heating and natural ventilation	322	65.71	391	C 54	Newbuild B 26 Typical of stock E 106	N/A	N/A	N/A	N/A

Source: Kovia

3 The case studies: Domestic properties

3.1 A. An off gas grid detached house in isolated rural location with LPG fuelled heating and hot water supplemented with solid fuel log burner

Age: Edwardian c.1910	
Construction: Solid stone walls (c.800mm thick granite with no cavity) dry lined. Glazed with 90% typical double glazed, wooden framed windows and French doors (installed c.20 yrs ago). Pitched slate roof has 400mm+ insulation. One open fireplace, two stories and eight heated rooms. Solid floors with underfloor heating with time and temperature control zones.	
Features: Large building with many architectural and decorative features.	
Use: Residential accommodation.	
Total internal floor area 274 m^2	
Main heating fuel: LPG Tank	
Primary energy use: 225 KWh / m^2 per year	
Building emission rate: 49.34 $kgCO_2$ / m^2 per year	
Pre-upgrade assessed energy rating: F 25 (Potential D 67)	
Pre-upgrade assessed CO_2 rating: E 43 (potential C 77)	
Background: House has underfloor heating and LPG gas boiler for heating and hot water which is leaking and old and inefficient supplemented with solid fuel log burner to main living space.	

3.1.1 The property is a large Edwardian home that currently uses LPG for heating and hot water. The building had undergone extensive renovation some twenty years ago when a new boiler and underfloor heating were installed. While the property is not listed it does have several original features throughout and also has very thick stone external walls (>800mm). The loft spaces have been insulated.

3.1.2 An assessment was undertaken as the occupier wanted to explore decarbonized solutions as the existing system was in a poor condition and requiring renewal soon. The assessment identified that internal and external wall insulation would help retain heat although air source heat pumps were not recommended in the assessment - according to the surveyor this was because of this scale and construction of the building which made them unlikely to be efficient solution.

3.1.3 The use of air source heat pumps was discussed with the occupant and when they mentioned that: “There is no way we are going to be able to afford or want to install internal or external insulation” this made air source heat pumps a potentially unviable solution (and in any case not recommended in the assessment).

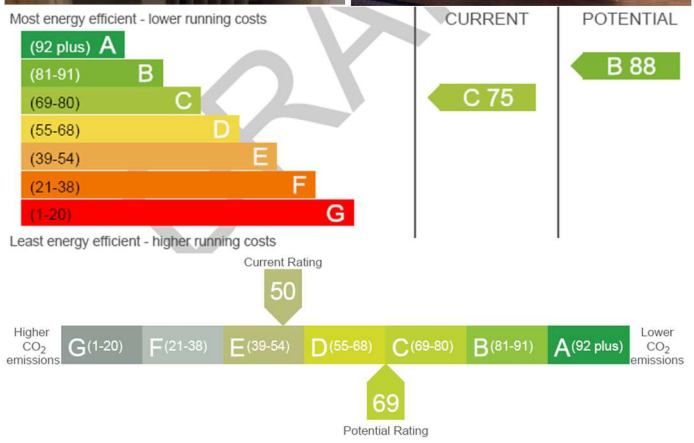
3.1.4 In winter the occupant “cranked up the wood burner” and had it running near constantly through the colder periods and “counted themselves lucky…” they “… were able to rely on a source of excellent dried wood”. The occupant noted “Unfortunately it was unlikely that we would ever qualify for support and given the scale of cost required to make the house more energy efficient put us off doing anything but a continuation of the existing situation.” The occupant noted “We will probably move to install a new gas boiler and look to see if that can be hydrogen ready or possibly investigate green biogas.” “It's unfortunate we have plenty of space outside and external outbuildings that could house a large number of solar PV panels but pointless if air source pumps will not work.” “We have looked at ground source heat pumps but again do not have the money available for them and in any case we're not sure if they would affect an adjacent stream or our drinking water borehole.” “Cost is without doubt the key factor preventing us decarbonizing now and I hope we can afford a futureproofed system before the one we have packs up.”

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- It is unlikely that this occupier will move to the use of heat pumps given the cost and impact on building aesthetic and the use of BioLPG and bioliquids might provide a cost-effective low carbon solution.

3.2 B. End of terrace bungalow in hamlet with solar PV

Age: c.1950s
Construction: A bungalow (1 storey) of block / brick cavity walls (c.290mm thick) with pitched roof. Roof with 300mm thick insulation. Four rooms, two heated, with suspended timber floors. Windows are all double glazed (pre-2002) with PVC frames and a glazing gap of 16mm or more. No fireplaces.
Features: Bungalow has electric heating and hot water and includes solar PV and High Heat Retention Storage Heating (HHRSH). Main heating includes CSD controlled HHRSH. Secondary heating with electric panel convector / radiant heaters along with 3.2 kw solar PV panels.
Use: Residential accommodation
Total internal floor area: 73 m^2
Main heating fuel: Mains electric with solar PV
Primary energy use: 260 KWh / m^2 per year
Building emission rate: 43.99 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: C 75 (Potential B 88)
Post-upgrade assessed CO_2 rating: E 50 (potential C 69)
Background: Historically the property had solid and oil fuel but had been replaced with electric heating and hot water and latterly with the addition of solar PV. This case highlights an issue where decarbonisation is not driven by a coordinated plan but



3.2.1 The property is an end of terrace bungalow of conventional build, constructed circa 1950. A whole house retrofit assessment was undertaken to establish if it benefited from any energy efficiency measures and then to make recommendations. It was identified that the main energy supply to the property was electricity which powered several electric convection heaters and High Heat Retention Storage Heating (HHRSH). Taking advantage of funding available the occupant had recently installed renewable electricity generating 3.24kw solar PV system which improved the EPC banding from an 'E' 53 to a 'C' 75. The assessment identified and recommended several other energy efficiency measures including cavity wall insulation, solar thermal heating, and floor insulation.

3.2.2 The occupier took advantage of funding available for solar PV system to provide renewable energy (rather than solely mains electricity) as well as internal insulation. The works to install the PV panels were rushed and the occupier was left with a leaking roof. The occupier noted "the contractors came from another part of England and the work undertaken was not fit for purpose as my roof leaked and has caused damage including the roof insulation". The occupier wondered "should the job have been commissioned if there were not the people locally to do it properly?" "They were clearly in a rush to get them done to move on to the next and now they have got to be taken off and re done." The occupier noted other work to install some areas of internal insulation was done at a different time and a by a different contractor adding that "the insulation works were also rushed and added to the disruption we've had to put up with".

3.2.3 When asked what the disruption looked like the occupier noted that "there weren't many places to shift furniture about in a small house."

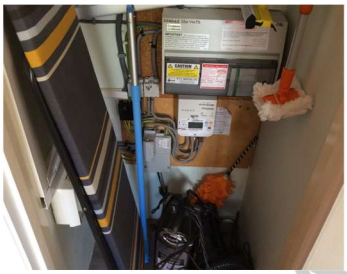
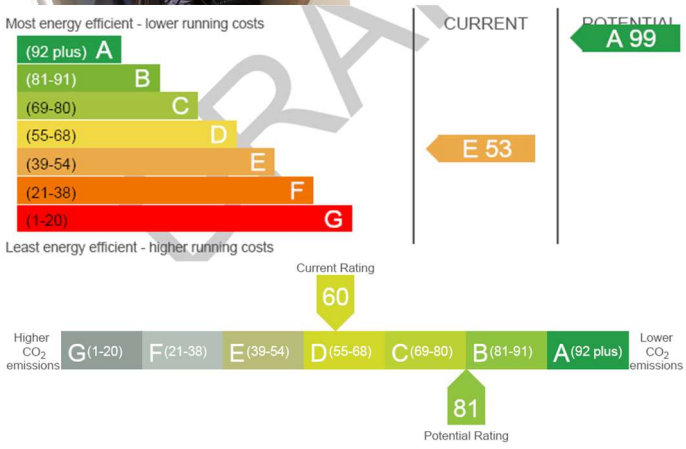
3.2.4 A minor positive from the situation was that the dehumidifier they have been given to address the water damage has "helped with damp elsewhere".

3.2.5 The occupier would have liked to further improve energy efficiency and have external insulation but can simply not afford it and explained that if there was money available, they were keen to reduce bills but had not necessarily done the work to meet any greenhouse gas targets. The occupier wondered "if this is what we are supposed to be doing why can't it be done properly in one go?" and "Surely is just a waste of money and time to do everything at different times with different people". While the property had a relatively low carbon impact (under the assessment model employed) occupants were not in a position to have any other energy efficiency work done unless further funding was available.

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they have both mains and solar electric for heating and hot water.

3.3 C. Mid-terrace bungalow

Age: 1960s	
Construction: Main building has block/brick filled cavity walls (c.300mm thick). The extension to the rear is solid brick without cavity / insulation (c.150mm thick). One storey with three rooms, none of which are heated. Solid ground floor. Pitched roof to main building with 200mm thickness of insulation in the roof. Flat roof to extension (as built). All windows are PVC double glazed (unknown install date) with a glazing gap of 16mm or more. No fireplaces or conservatories.	
Features: Low income household	
Use: Residential accommodation	
Total internal floor area 45 m^2	
Main heating fuel: No main heating system. Mains electric with 3.2 kw solar PV panels.	
Primary energy use: 305 KWh / m^2 per year	
Building emission rate: 51.61 $kgCO_2$ / m^2 per year	
Post-upgrade assessed energy rating: E 53 (Potential A 99)	
Post-upgrade assessed CO_2 rating: C 60 (potential B 81)	
Background: Premises now all electric heated with High Heat Retention Storage Heaters and includes solar PV. While clean low carbon source the components that were affordable and installed do not reportedly comprise an energy efficient system.	

3.3.1 The property was constructed of conventional build, c.1960s with electric heating as the main heat source. While the property had solid floors the cavity walls had been filled to the main building. There was no central heating system and relied on electric heaters. Hot water was generated by an insulated electric emersion heater. The assessment recommended an upgrade to the water heating to High Heat Retention Storage Heating (HHRSH) and further insulation to internal / external walls, ceiling, and floors.

3.3.2 The occupier had a smart meter fitted and also a High Heat Retention Storage Heater, but the latter was found to be “useless and expensive” it had “not helped with heating costs at all”. While it caome on at night when electricity costs were lower and when the PV panels were not working electricity costs for heating (even with solar PV panels) were felt to be high for this occupier and created “a black cloud hanging over us”. The occupier noted that they “had not been able pay the last few bills”. The one positive was that the “new energy meter has helped us see where the costs were.”

3.3.3 The occupier reported that the meter illustrated that “The small electric heater works out cheapest to use”. The occupier noted that the works had caused some disruption and not helped addressed their energy costs which were higher although unclear if this was as a result of additional heating installed or more general increases to electricity prices The installation of low carbon and energy efficiency measures occurred only when the occupants were aware funding was available and in the hope that it would reduce running costs.

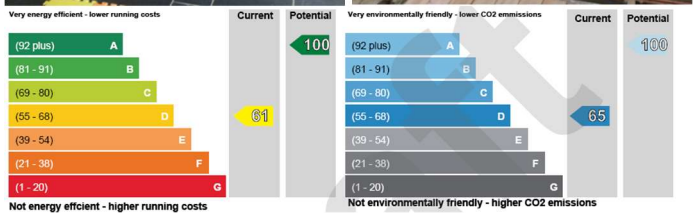
3.3.4 The occupant confirmed that they were “not worried about the greenhouse effect, we just want to afford to be warm.”

3.3.5 his case study illustrates the options and actions some rural homes are taking and that in this case motivated more by high energy costs rather than decarbonisation. It also illustrates that for some people actions will only be taken where there is a financial incentive to do so.

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they have both mains and solar electric for heating and hot water although they are reportedly not working efficiently.

3.4 D. Semi-detached home property within a rural village

Age: Victorian c.1900	      
Construction: Stone walls to main building and block-built extension to rear. No loft or wall insulation.	
Features: Extended to rear.	
Use: Residential accommodation	
Total internal floor area 128 m^2	
Main heating fuel: Had air source heat pump fitted.	
Primary energy use: 211 KWh / m^2 per year	
Building emission rate: 35.66 $kgCO_2$ / m^2 per year	
Post-upgrade assessed energy rating: D 61 (Potential A 100)	
Post-upgrade assessed CO_2 rating: D 65 (potential A 100)	
Background: Originally solid fuel source heating with an air source heat pump installed although problems have arisen not least because of poor installation but also a lack of consideration of whole house solution.	

3.4.1 The property is constructed of traditional build circa 1900 with a conventional constructed extension added later. The occupier's intention was to install an Air Source Heat Pump (ASHP) moving away from the current heating platform of solid fuel (a wood burner and open fireplace in the main living space.

3.4.2 An energy assessment produced a number of recommendations including, loft insulation, internal / external wall insulation, floor insulation, hot water cylinder insulation, solar thermal or solar PV. Whilst a number of recommendations were made as a result of the assessment, the priority for this particular property reflecting funding available was to install an ASHP. An ASHP was installed at a cost c.£9,000 and the EPC banding changed from an 'F' 27 to 'D' 61.

3.4.3 Unfortunately, the occupant explained, “the air source heat pump has not performed well”. The occupant further explained that “last year (2022) they (the installers) started with the installation of an air source heat pump, and I still have no heating or hot water working properly now”. The occupant explained “they use subcontractors who completely made a hash of putting in the system” first time round. “They've now put another guy in who has re-done most of it, but the original lot, when they wired up the air source heat pump, … damaged the unit”. The occupant further explained their reasons for suspecting poor performance on the behalf of installers: “I understand it (the heat pump) to be ‘closed unit’ and you've got an in and out and, some power and new pipe work and I would have thought it all would have been completed in three days. We are now coming up for the anniversary since they started and there is not a complete working system”.

3.4.4 The occupier continued: “The thing is, it (the air source heat pump) is working against itself at the moment, we have a log burner stood in the kitchen with the chimney going through the roof and you can think about all the cold air rushing down that and the other chimney in the house” … “at the moment is never going to be that efficient and needs to have been designed with measures to heat a whole house and hot water, and cook.” The occupant reported that the air source heat pump “in one night when it went into frost protection mode, “it burned 64 kW of electric.” It is noted that the house lacks other insulation to internal and external walls and other measures that would help the air source heat pump work more effectively.

3.4.5 The occupant noted that decarbonisation was taking place in an ad hoc way and not necessarily achieving the basic of needs: “the way it (the heating system including the air source heat pump) is planned, it still doesn't heat up the back half of my house. I'm still lighting the two fires in the lounge to keep it warm, so my feelings are that I am probably not the best one to be asking for someone to make a statement about green energy.” “I think had it worked I would be possibly singing a different tune.”

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating although it is reportedly not working efficiently.

3.5 F. Converted barn set within rural farm.

Age: Pre-1900
Construction: Thick traditional stone walls (granite) without insulation, slate insulated roof. Two storeys. Non-PVC double glazed windows throughout.
Features: Barn conversion
Use: Residential accommodation
Total internal floor area c.120 m^2
Main heating fuel: Oil
Primary energy use: Unknown
Building emission rate: Unknown
Pre-upgrade assessed energy rating: Unknown
Pre-upgrade assessed CO_2 rating: Unknown
Background: The barn has been converted in the last ten years and an oil fuelled AGA was installed.

3.5.1 An energy survey has not been completed for this property although it was inspected as part of the interview with the occupier.

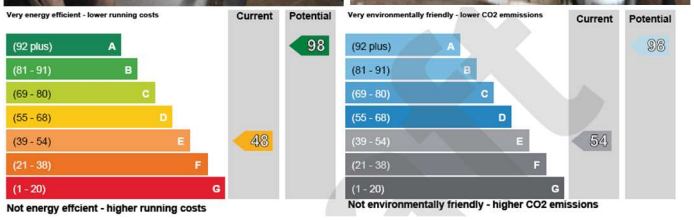
3.5.2 The house is the home of a young busy farming family, and the main source of heating is an oil fired AGA which has a back boiler and three radiators. Elsewhere the property has some electric panel heaters. The occupier describes the heating as “It does work, particularly in the main living areas upstairs. The house is an up-side-down house and the bedrooms are downstairs and as part of the house is built into the slope can be quite cold in those rooms.”

3.5.3 When asked about replacing the oil fuel AGA to decarbonise the property: "Absolutely no way I will replace the AGA, it's the heart of the house." The occupant explained "I can dry clothes in the room with it and it really makes this a farmhouse. We were so lucky to be able to get hold of one when we were rebuilding the barn and never thought to look to see if there were any alternatives." When asked if they could upgrade anything about the house they noted: "We just don't think we could afford to do anything with the AGA although I don't know if there is an alternative fuel out there? We can't change the walls as they are all stone and a real feature of the barn which will stay".

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- It is unlikely that this occupier will replace their AGA move to the use of heat pumps given the cost and impact on building aesthetic and the use of BioLPG and bioliquids might provide a cost-effective low carbon solution.

3.6 G. Victorian rural property undergoing refurbishment.

Age: Victorian (Pre 1900)	
Construction: Stone walls, solid granite without insulation or cavity.	
Features: House with period features. Slate pitched roof with minimum level of insulation. Suspended timber floor and several open fireplaces retained throughout. Windows are not double glazed.	
Use: Residential accommodation	
Total internal floor area 145 m^2	
Main heating fuel: Had air source heat pump fitted along with solar PV.	
Primary energy use: 221 KWh / m^2 per year	
Building emission rate: 37.41 $kgCO_2$ / m^2 per year	
Post-upgrade assessed energy rating: E 48 (Potential A 98)	
Post-upgrade assessed CO_2 rating: E 54 (potential A 98)	
Background: Survey undertaken post install of air source heat pump (which replaced fuel oil heating and hot water system). While the structure is not listed, upgrades to wall insulation are not being taken forward.	

3.6.1 The property is a detached house constructed of traditional build (stone), built c.1900. The building formerly had a fuel oil heating and hot water system.

3.6.2 An assessment was undertaken post installation of an air source heat pump. The assessment identified potential energy saving using internal / external wall insulation. While the structure is not listed, upgrades to wall insulation are not being taken forward. In addition, the occupier wanted to continue to use solid fuel, retaining the use of several fireplaces.

3.6.3 The assessment post air source heat pump was not significantly better than the previous situation (also an 'E') and interpreted in this case the heat pumps may not function as well without other measures to change the potential energy loss through walls and chimneys. The occupier did not want to change the internal or exterior appearance of the building. Discussing the reasons for this decision revealed some interesting differences with the assessment.

3.6.4 The occupier explained the motivation to decarbonise; "we were spending a lot of money renovating the property and the builder just said that it would make sense putting in an air source heat pump". The occupier noted that they received funding for it, and it had been working satisfactorily. The occupier was asked why more insulation (mainly of interior and exterior walls) was not applied and the occupier noted that they had "read up a lot about this, a key part of the renovation was to make it watertight and dry, and this is not damp house, and we were concerned that addition additional layers might increase the chance for moisture to collect." Furthermore, "it's not the biggest of houses and it would have really compromised the amount of space and look of internal walls". The occupier had also learnt that "a dry-stone wall has a thermal mass and once the house is, like, up to temperature it can retain heat.

3.6.5 "Additionally, because we've got a lot of small air gaps between the main walls and the internal walls it allows the house to 'breathe' and if you start messing about with that you start having problems with damp … so we didn't want to mess with the house that functions well already". The occupier felt there were a number of "models and nonsense that are out there don't necessarily work for all houses". The occupier felt they were not "paying ridiculous heating bills and our heating bills are not stupid". The occupiers also had installed solar PV with battery storage: "with batteries, that that's a game changer really … in the summer we don't have heat and the air source can act to cool. The only heating bill is an electric bill."

3.6.6 The occupier had little negative to report from their experience decarbonising the property and were fortunately in a position financially to undertake the works and benefited from being able to do the works at the same time a renovation which "saved money and inconvenience."

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating.

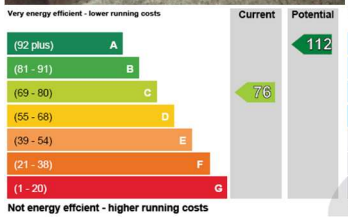
3.7 I. End of terrace bungalow in rural village

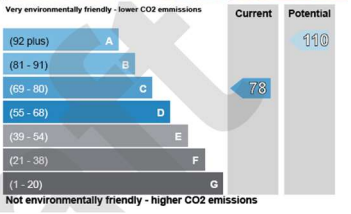
Age: Estimated to be late 1960s
Construction: Conventional block / brick cavity walls. Cavity walls are not filled and the loft uninsulated. Solid ground uninsulated floor.
Features: Property previously fitted with solar PV and utilised oil fuel.
Use: Residential accommodation
Total internal floor area 116 m^2
Main heating fuel: Had air source heat pump fitted and solar PV
Primary energy use: 93 KWh / m^2 per year
Building emission rate: 15.64 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: C 76 (Potential A 112)
Post-upgrade assessed CO_2 rating: C 78 (potential A 110)
Background: Property benefited from solar PV and had an air source heat pump to replace oil fuel heating. Survey inspected installation and noted that much more could be done to make property efficient.











3.7.1 The property is constructed of conventional build c.1968 and had an oil fuel boiler and stove. The occupant has been trying to replace oil and took advantage of a funding opportunity to install solar PV and then more recently an air source heat pump. An energy assessment was undertaken post installation of the air source heat pump and recommendations were made to improve energy efficiency including cavity wall insulation, loft insulation, wind turbine, low energy lighting, and solar thermal.

3.7.2 Discussions with the occupant revealed that one of the occupants had a health condition and needed a warm house. They did not feel the conversion was “extremely expensive” although this reflected the fact that in this case the works had been subsidised by grants and were not aware of full costs. The occupants were committed to a self-sufficient trajectory and also had their own borehole water supply.

3.7.3 The greatest misgiving, they had about the work undertaken was that they "didn't have a lot of trust in the contractors doing the install" and they told the occupant they needed to get the "job quickly finished so that they could get back to the previous mistakes they had made on earlier jobs that day". The occupant noted that they were "receiving phone calls that were going on whilst he was actually doing the job." When they initially started work at this property "the whole system (was fitted) absolutely wrongly at the beginning as the cupboard door didn't shut then we couldn't get through the door of the room". They had to "…come back to look at a little leak and they told me that 'the leak was fixed' but and then they said quite flippantly 'everybody has that trouble with the message on the machine, just ignore it, everybody does' and I thought, 'well it's a new system - that can't be right', it irritates me that every week we get a warning saying that something hasn't been done properly. I've sent them many emails about it."

3.7.4 As part of the upgrade, works were organised with a different company to take the old boiler out – although the tank which was emptied of oil - was left behind.

3.7.5 The occupant was asked what they felt the overall impact of the upgrade (from oil boiler and cooker to air source heat pump and solar PV): "we had an absolutely ancient old Stanley boiler which is based on a sort of Aga type thing and although it was old, cranky and smelly and probably broke all the carbon dioxide rules it was quite efficient because it had a back boiler on it. We paid for that oil each year and, actually, because we have a small bungalow and it's not too badly insulated, so it did very well. It did very, very, well and we missed it terribly to begin with because one of the major things for me was that I could dry my clothes all around it in the winter". Despite missing the ability to dry clothes and …" the occupant noted that "we haven't got the dangerous carbon dioxide, or is it monoxide?" and that it was "very difficult finding anybody that would service it - it was on its way out - so we were very, very, glad to have a new system put in."

3.7.6 In terms of the new system the occupant noted "It took a bit of getting used to, particularly the idea that you have it on all overnight, but once we got the idea of it, it was really good. I thought it's brilliant and the way it keeps it warm without the heaters being on fully is fantastic." In terms of a negative relating to noise created from the air source heat pump the occupant noted "it's good that we live out in the 'sticks' so we don't have to worry about fan noise - I've heard other people complaining about the fans making a lot of noise. While it does make some noise … it certainly doesn't upset us."

3.7.7 The occupant explained that at the early stage in the installation process they were surprised at how many people and visits it took before someone came and fitted the system: “We were apprehensive as we had so many people come and look at it and wondered if it was some sort of joke and we started to almost think ‘is this a scam?’… it made us suspicious, and we were at the point of ‘saying forget it’, … we really were pestered and … they were measuring the most peculiar things, like, the gaps between the door and the carpet, and it was very odd.”

3.7.8 The contractor had designed the system and the occupant had the “floor plans back and they were completely wrong … they didn't even have whole bedroom and just forgot the whole back of the house…”. The occupant wondered “I know it's a new technology, but it's not rocket science?” The occupier added “I think the main problem with the fitters is they're trying to rush and because they're trying to do it for next to nothing” (to within money available) “…they make mistakes … and … it's inefficient because they end up having to go back to redo the things that they did wrong in the first place.”

3.7.9 The occupant noted that on balance they felt “I think it is a good system, I would recommend it.”

3.7.10 In terms of potential financial savings, the occupant noted that “We didn't have an electric bill that high before … but we don't spend £2,000 a year for oil now. We are spending about the same (as we did before) whereas everybody else's prices have gone right up.” “The playing field changed, and we have got solar PV and we don't know how much the solar panels really contribute I guess more than we know.” (The occupant also noted that there were problems with the installation of the PV panels – they were faulty and had to be replaced fortunately under warranty).

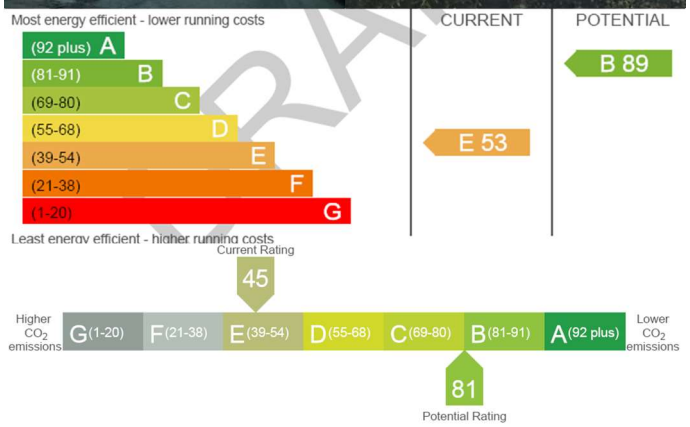
3.7.11 It is not clear if the occupants were actually receiving the full benefit from the system they had installed as they noted: “the other thing was that they never really, because they're in such a rush, they never took the time to really show us how the system works… or tell us what else we could do, you know and I am sure we are not using it completely right.” In addition, one of the occupants had poor health and that had prevented them being able to “make the outside of the house a lot more efficient (with external wall cladding and window replacement)”.

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating.

3.8 K. Domestic Former Stone Farmhouse

Age: Pre 1900
Construction: A two storey farmhouse with stone walls (granite) without cavity or insulation. The wall is estimated to be 730mm think. Pitched roof with slate and 300mm of insulation. Suspended timber floors with no insulation. Seven heated rooms, three doors and PVC double glazed windows throughout (with 16mm or more glazing gap). Home fitted with radiators from oil fired boiler. Condensing boiler also heats water and retained in hot water cylinder. No solar PV panels.
Features: Triple glazed and loft insulation
Use: Residential accommodation
Total internal floor area 231 m^2
Main heating fuel: Oil with solid fuel.
Primary energy use: 186 KWh / m^2 per year
Building emission rate: 49.03 $kgCO_2$ / m^2 per year
Pre-upgrade assessed energy rating: E 53 (Potential B 89)
Pre-upgrade assessed CO_2 rating: E 45 (potential B 81)
Background: Traditional rural farmhouse with fuel oil heating and hot water.



3.8.1 The property is of traditional build, constructed pre 1900 with oil/solid fuel as the heating source. The assessment made a number of recommendations including floor and wall insulation as well as solar thermal and PV.

3.8.2 The occupiers were tenants and had been working to make the building more energy efficient since they moved -in: “The landlord agreed to meet us halfway with the replacement to the old single glazed windows and we have been trying to get them to pay for the front door which we had to replace and upgrade.” The occupier noted that when they moved in, they found that they needed to insulate the roof: “The area around the loft hatch had a good double thickness of insulation but elsewhere was very thin”.

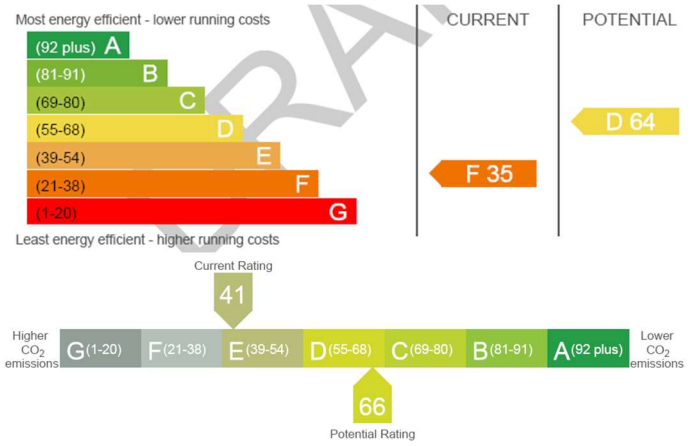
3.8.3 The occupiers were really keen to become more efficient and decarbonise but were limited in their position as tenants “we can’t do anything about the fuel-oil system and know that it is unlikely that the landlord will pay to upgrade the floor and wall insulation unless something goes wrong.” The assessment report highlighted that the building was currently an “E” rating and would not require any action although the requirement was set to change and the government aims for rented properties to be at a band C by 2030 (where practicable, cost effective and affordable). The occupier noted “I’m not sure how we would achieve that without it being a requirement and in any case that is going to mean more difficult conversations with our landlord and I can’t see how we would contribute”.

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have an effect on the landlord. It is unlikely that the tenants (a retired couple) would be in a position to share costs and pay to install heat pumps and the use of BioLPG and bioliquids might provide a cost-effective low carbon solution.

3.9 L. Extended end of terrace stone cottage

Age: Pre 1900 with 1970s and 1980s extensions.
Construction: Stone (granite) 575mm thick walls to main building with pitched roof and 150mm of loft insulation. Second building (first extension to rear for kitchen) has c.320mm thick block walls with filled cavity and a pitched roof with 150mm of loft insulation. Third extension is of solid brick c.250mm thick (uninsulated) and a pitched sloping ceiling. Solid uninsulated ground floor throughout. All windows are double glazed with PVC frames and an unknown install date (assumed 20yr+) and glazing gap of 16mm or more.
Features: Solid fuel and electric heating and does not have central heating system.
Use: Residential accommodation.
Total internal floor area 84 m^2
Main heating fuel: Electric heating with proposed solar PV with solid fuel wood burner
Primary energy use: 375 KWh / m^2 per year
Building emission rate: 65.70 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: F 35 (Potential D 64)
Post-upgrade assessed CO_2 rating: E 41 (potential C 66)
Background: Building relies on solid fuel and electric heaters with the occupier wanting to install solar PV as a priority rather than heat pumps.



3.9.1 The property is constructed of traditional build, with the front constructed pre-1900 together with a kitchen in the 1950's and more recent block-built extension to the rear. An assessment (energy report) was undertaken on the premises to make recommendations for energy improvements and highlighted that several works would help make the property more efficient including internal/external wall insulation, floor insulation, solar photovoltaic panels and solar thermal panels. It is noteworthy that heat pumps are not recommended by the software used in the assessment (The current assessment model used is called RdSAP 2012 and an awaited update should address this). In this case, the occupier was looking to install solar panels as a priority.

3.9.2 The occupier was happy to try and become more energy efficient although their ambition was limited by financial support available; "I can only afford to do what I can get help with. If I could get further support, I would have undertaken more although I only had a grant for solar PV panels." As a result measures had been undertaken in a piecemeal approach "I am not sure that I can 'get' insulation - I have three parts to my house one is a cottage at the front which is really old with an original slate floor, I've got a 1950's kitchen extension which has had some cavity wall insulation, and then I have a single storey large garden room which is insulated and built in the last ten years and insulated (floor, walls and roof). There are some parts that are well insulated and some not at all. At the front and side there are two walls that are not insulated and nearly three feet thick stone walls. In the cottage I have a wood burner". The house does not have a central heating system. "I've actually bought two of the German electric heaters which store the heat with ceramic blocks. I don't have anything upstairs other than plenty of duvets and blankets although we have moved our bedroom downstairs." In terms of other potential sources of heating the occupant noted: "because we have no mains gas, which is been phased out now, and also that LNG is so expensive, they offered me one of those new air source heat pumps with radiators. I'm very keen, except for the fact that when I ask them how they would do it, it sounded like my house would be ripped to pieces and I would have pipes everywhere which they admitted that would be left for me to arrange so I said, 'well I think I'll pass on that'." "When they explained where the pipes would go, it wasn't too bad for upstairs he said 'you come in at the side and you go under the floor' although he said he'd have to get access to your floor. Well, I'm 70 nearly I can't move my double bed and he said 'it would have to be clear and ready' for them. I can't do that, that's just ridiculous. The for the lower floor at the front they said that because the walls are so thick and there are slate flag floors - they have to come in wherever they could. I asked if I would I see the pipes he said 'yes' and there would be the problem of getting access again. I just had all that part of my house redecorated and parts replastered a couple of years ago and it looks glorious, and I just couldn't bear the thought of going through and recking all that good work."

3.9.3 The occupant was asked what they thought the upside of a new system would be: “While I think it will give me a heating system, I decided I preferred the impact of solar PV panels which would only affect the roof and you don’t see, and they have been fantastic.” The occupant’s reasoning for solar PV included: “I would have had more but I could only have certain amount. The solar panels help contribute towards the energy for the ceramic heater. They also work all the time, it's a myth that they only work in sunlight, and it is only really on a really black cloud day they would not do as much.” When asked if there were any negative points the occupant noted they had to “wait months and months, … it took more than half a year to get them installed.” The occupant was asked if there had been improvements to their quality of life because of the measures installed (including solar PV) “Not massively, but I know more about my energy use. I can see from the meter that it all works so well in the summer. When I actually monitored exactly what was happening and what it (the solar PV) was paying for - it won't do all my electricity in the winter but in the summer, it covers everything except for the (hot water) immersion heater, it doesn't like that. I'm very economical since I can see my usage and I don’t heat water unless I need to. I also stagger my use, so it does not go above electricity from panels.” … “I just wish I could have had more (panels).”

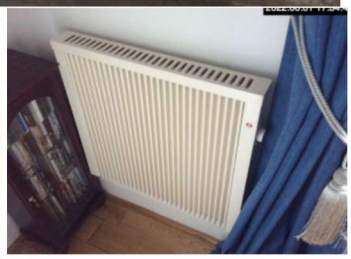
3.9.4 Discussing the occupant’s switch to a renewable energy it was clear that greenhouse gas emissions were a secondary consideration: “Two years ago schemes available to me offered me a central heating system although my garden was not big enough to have an underground storage tank (for LPG) I would actually have loved that. They offered me bottle gas and before I made a decision the scheme had changed, and I was offered solar panels and air source heat pumps.” “They also tried to offer me interior wall insulation … and as I had had my walls re-plastered, I did not want them being messed around with.” “I actually felt with the older part of the house so long as I have the wood burner going every so often and heated the stone walls and state floor the whole of the room gets warm and cooking.” The occupant also noted “The front of the house is also nice and cold when it is a hot day. I now use just kiln dried logs and has made a real difference, although there are problems of delivery. As I'm getting older and (the logs are) delivered to the doorstep, I have to carry them in which is difficult and not as easy to source / collect in rural areas”.

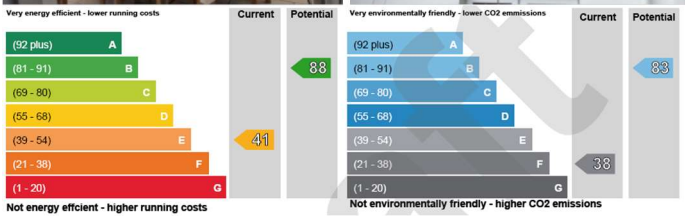
Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they have solar PV fitted although there is a reliance on solid fuel heating in part of the house.

3.10 M. Mid-terrace property with recent heat pump installed.

Age: Pre 1900
Construction: Main building of two storeys with stone walls (c.600mm thick granite, no cavity and uninsulated) and pitched roof with 270mm of loft insulation. Single storey stone (c.460mm granite no cavity and uninsulated) extension to rear with simple uninsulated sloping roof and adjoining conservatory. Windows are double glazed throughout (PVC). Solid uninsulated floors throughout.
Features: Occupier uses heat pumps along with solid fuel and electric heaters
Use: Residential accommodation
Total internal floor area 46 m^2
Main heating fuel: Air Source Heat Pump with solid fuel with secondary electric panel, convector or radiant heaters.
Primary energy use: 437 KWh / m^2 per year
Building emission rate: 89.14 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: E 41 (Potential B 88)
Post-upgrade assessed CO_2 rating: F 38 (potential B 83)
Background: Inspection post installation of heat pump identifies scope for greater efficiency although impractical to install more insulation.





3.10.1 The property is constructed of traditional build (rendered stone), circa pre 1900 with solid fuel heating. The client had an air source heat pump installed and an energy assessment was undertaken post installation. The assessment found that the property still had a low energy rating ("E") and indicated that the property would still benefit from insulation and would also ensure the heat pump worked efficiently.

3.10.2 The interview was conducted with the daughter on behalf of the occupant who was elderly. The air source heat pump had made the house a little warmer. The occupant formerly "had electric radiators and a wood burner that that cost a lot more to run." A significant part of the property retained "it's 300-hundred-year-old walls with no insulation". The occupant was asked if the system worked or was efficient without the property being insulated and they noted: "it's working okay, you've got the benefit of 'thermal return' from the stone walls, haven't you, so when it's warming up, the walls heat up and send heat back into the rooms. These older properties really do benefit from it but the models that they use to assess energy to get the grant funding don't seem to take it into account. Before the air source heat pumps Mum had independent electric radiators which were so expensive to turn on that she wouldn't. When it was cold, she was mostly sat in with her single wood burner … really only heating one room and then staying there." The occupant confirmed a benefit of the new system was that "…now hopefully she can get around a lot more in the house and she is feeling a lot better about it." In terms of the wider benefit this had provided the occupant noted "she's not suffering the cold so much … and as she will be 80 next year so will help with her health."

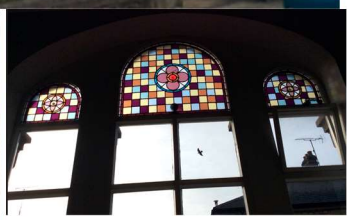
3.10.3 In this case the occupant has run with different approach to decarbonise their home taking in the "thermal return" expected from heated stone walls. It is likely that the heat pump would be more efficient heating up the house from cold if it was better insulated and not working to warm the stone walls which are likely to be beyond their design capacity. It was too early to confirm if there was an overall net increase in energy (electricity) consumption.

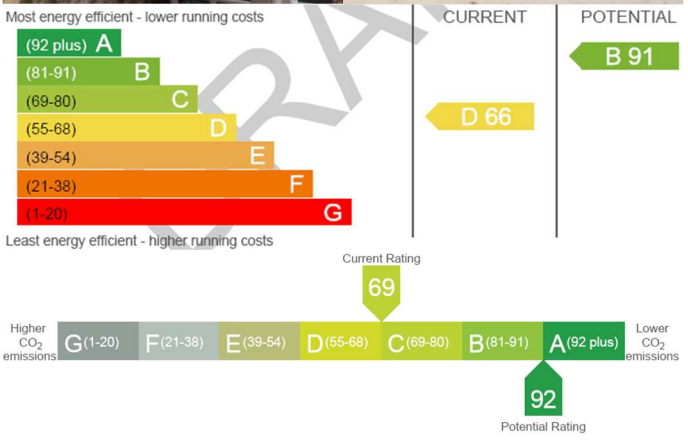
Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating.

3.11 O. Converted Grade II property within a rural village.

Age: Victorian (Pre 1900)
Construction: A main building of two storeys constructed with timber floors (retrofitted with 150mm of insulation), stone walls (granite, c.530mm thick, uninsulated) and pitched slate roof with c.150mm of loft insulation. The extension (contemporary to main building) has a solid floor (uninsulated) stone walls (uninsulated and c.530mm thick) and pitched roof with c.200mm of loft insulation.
The property comprises four heated rooms and only approximately 70% of windows are double glazed (non-PVC frame and unknown install date). The remaining large single glazed windows to the main façade are single glazed and listed.
Features: Listed (Grade II) structure
Use: Residential accommodation
Total internal floor area 119 m^2
Main heating fuel: Air source heat pump with radiators. Secondary heating provided by a RDM closed room heater.
Primary energy use: 163 KWh / m^2 per year
Building emission rate: 27.58 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: D 66 (Potential B 91)
Post-upgrade assessed CO_2 rating: C 69 (potential A 92)





3.11.1 This property is a semi – detached, Victorian stone-built Grade II listed building. The building was originally a "Literary Institute" and subsequently converted to residential accommodation. The Grade II listed status applies to the frontage and associated windows which must be retained reducing options for internal or external insulation.

3.11.2 A post-installation survey and assessment was undertaken of a new electric air source heat pump that replaced an 'early generation' air source heat pump. An EPC was lodged to show that the new heat pump had moved the property to an overall good rating of "D 66". The assessment recommended Internal/External Wall insulation, but due to the historical nature and age of the building this created several challenges – the listing reduces the amount of internal works and change to external areas. Internal wall insulation was possible but would need to use traditional materials and impact on cost.

3.11.3 While the historical nature and age of the building constrains the opportunities available for further energy saving, a reasonable energy efficiency level can still be achieved without the need to make drastic changes to the fabric and character the building.

3.11.4 The occupier confirmed that the objective was "to make it liveable again" and "…as it was formerly an 'F' rating, ideally, make it more sustainable … so a new heat pump and under floor heating". The occupier was looking to change the amount of insulation in the building "I'm looking to now try to increase that and to what it needs to be…" although there is "…still some way to go and is and because it's a historic building there are significant costs and probably hassle involved with upgrading the insulation." The occupier explained that "single glazing at the front of the building has to be retained…" because of the listing. The occupier was committed to improve "I'm hoping to do what I can to get it up to where it needs to be, and I recently researched the new financial support available to see if I can get a grant to help with installation. However, it doesn't look like that's possible at the moment - it looks more like its funding for just one form of insulation and will not suit this property." The new system was "looking like it's going to save about 30% on energy costs." although the occupier noted this could be better if further insulation and potentially solar PV could be fitted. While the occupier had been financially in the position to renovate the building, since they took possession grants had made the difference to their ability to become more efficient and decarbonised.

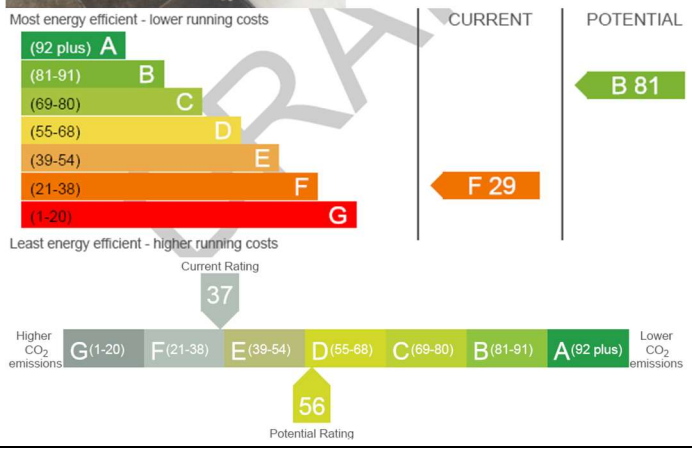
3.11.5 Works that had been undertaken had been moving the property towards decarbonised and efficient energy and had also tackled some other issues: "the ventilation and heating within the building was not working so the whole house was mouldy so the air quality has really improved. The new system of heat pump with underfloor heating and some radiators have cleared that issue up." The occupant described that the grants available have helped bring the building back to life and "The building was featured in the local magazine the other day and at Christmas just having a bit of life in it, it has brought some character back to this corner of the village."

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating.

3.12 P. Detached cottage on edge of rural town with conversion from off-grid LPG to electric heating

Age: Pre 1900
Construction: The main building is of two storeys and has stone walls (c.580mm thick granite or whinstone that has been dry lined), and a pitched roof with 75mm of loft insulation. A single storey extension (built c.20yrs ago) is also of stone (c.340mm, as built) with a sloping ceiling and a second two storey extension with filled cavity walls and pitched roof. It is not known if the second extension benefits from loft insulation. Solid floors (uninsulated) and non-PVC double glazed windows (unknown install date) throughout.
Features: Small detached cottage with more recent extensions
Use: Residential accommodation
Total internal floor area: 100 m^2
Main heating fuel: Mains and solar PV
Primary energy use: 392 KWh / m^2 per year
Building emission rate: 68.19 $kgCO_2$ / m^2 per year
Post-upgrade assessed energy rating: F 29 (Potential B 81)
Post-upgrade assessed CO_2 rating: F 37 (potential D 56)
Background: Original off-grid LPG replaced with electrical heating and hot water systems. Recent work to insulate roof and ventilate premises examined in survey.



3.12.1 A number of works had been undertaken on this property in an attempt to decarbonize energy sources and make it more energy efficient. The occupier had the benefit of some of their costs covered for loft installation and the installation of solar PV (mainly taking advantage of funding programmes available). The loft installation was topped up to 300 millimetres (post survey bring to an E). A post completion survey and assessment of these elements was undertaken in April 2022.

3.12.2 As the detached cottage was constructed at the turn of the last century, the assessment identified that additional mechanical ventilation (a ventilation strategy led to the install of a Positive Input Ventilator above the stairwell) could help increase the performance and energy efficiency. The assessment included other potential measures including internal wall insulation yet was considered by the occupier to be too costly and impractical to install given the impact on internal space within the dwelling. Heat pumps were not recommended in the assessment and may be because of the age and construction of the property and that it lacks a central heating system.

3.12.3 As the property and relies on electric heaters, the occupier noted that this was very expensive: “we are running this only when we need it and I'm in a scarf at the moment.” …” It’s frustrating because public money has been spent and it's only sort of a ‘half job’ isn't it?” The occupier noted that “We still have damp problems and might be because we still are uninsulated and don’t have a central heating system”.

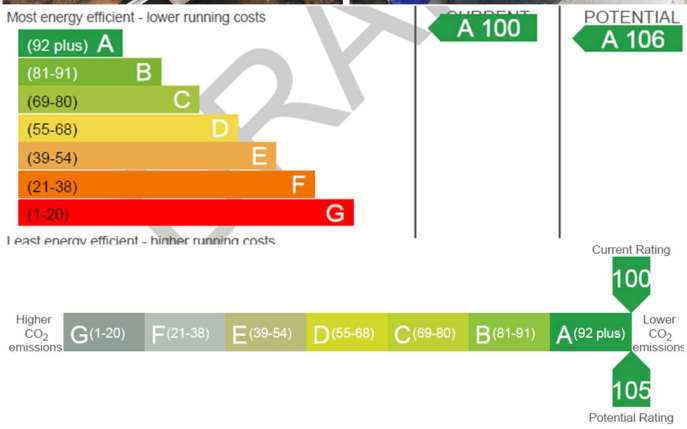
3.12.4 The occupier was not in a position to undertake any further works…”we have been relying on grant money to undertake any work and would like some more insulation, which makes sense, and would probably make it all more cost efficient.”

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have solar PV and mains for heating and hot water. The current system is reportedly not working efficiently.

3.13 Q. Upgraded and renovated detached 1970's bungalow in village.

Age: Originally built in 1970s
Construction: Main building is a single storey and has filled block cavity wall (c.300mm thick) with slate pitched roof (c.200mm of loft insulation). Four heated rooms. Solid floors undergoing replacement at time of interview. PVC double glazed windows of unknown install date throughout.
Features: Occupier able to undertake work to upgrade heat and energy systems
Use: Residential accommodation
Total internal floor area 124 m^2
Main heating fuel: Heat pump with underfloor heating, solar PV and mains
Primary energy use: -34 KWh / m^2 per year
Building emission rate: -5.78 $kgCO_2$ / m^2 per year
Pre-upgrade assessed energy rating: A 100 (Potential A 106)
Pre-upgrade assessed CO_2 rating: A 100 (potential A 100)
Background: Originally off-grid fuel oil upgraded to mix of electric heat pump (air), solar PV and solid fuel (wood burner). Survey provided post installation certificate for heat pump.



3.13.1 The property is a detached bungalow of conventional build, constructed circa 1976. The property had until recently an oil-fired boiler for hot water and heating. The occupier had recently purchased the bungalow and was renovating it to his specification. In an initial stage of work the occupier had installed solar PV panels as well as a solid fuel log burner to the main living space for winter top up. In the most recent work the occupier had a heat pump installed. A post install EPC was conducted following the installation of the 8kw Air Source Heat pump and made a number of recommendations for potential floor insulation, heating controls and potential use of solar thermal measures.

3.14 The installation of an air source heat pump reportedly cost c.£9,000 to install (the occupant received £5,000 in grant) and, combined with other measures in place took the EPC rating from a band 'C' 72 to a band 'A' 103.

3.15 This bungalow is typical of many others of this type and age within the village yet in this case the occupier benefits from the time, income, and capacity to realise their ambition for an energy efficient decarbonized home.

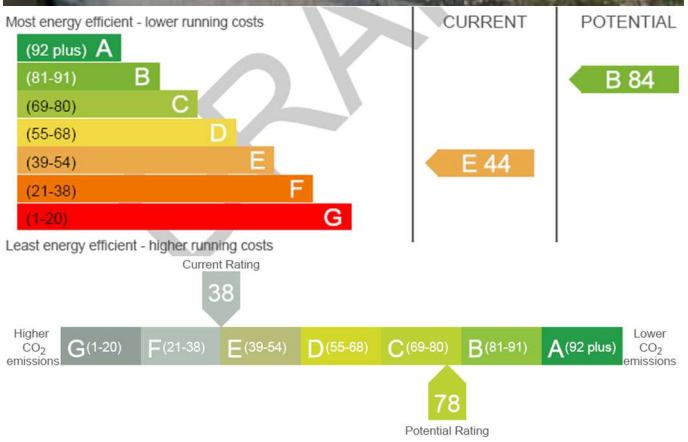
3.16 The occupier explained that they were fortunate to be in a financial position to be able to renovate the newly built property having been motivated to sell a very inefficient house in the country. Both the occupant and a tenant were experienced builders and "breaking out the solid concrete floors with mini-diggers and 'wacking in' lots of underfloor insulation and heating was easy." While the occupant had some funds, grants were still important: "I got £5000 from government to go from gas to the air source pump … as well as …. A grant to put 10 kilowatts of solar panels on the roof. I purchased a 10-kW battery. In total it's probably cost me around £30,000." The occupier noted that "people expect work like this to pay for itself in 'X' number of years, but I'm 66 at the moment and not in great health so I needed it now. Would probably pay for itself well before I die." In terms of other works the occupant noted that "I was lucky, there was already filled cavity wall insulation, so there's not much more to do when the floor is done".

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no effect on this occupier as they now have an air source heat pump for heating with solar PV power.

3.17 R. Terraced stone cottage with oil and solid fuel within village.

Age: Pre 1900
Construction: A building of two storeys with four heated rooms. The walls are of stone (Granite, c.730mm thick, without cavity or insulation) and has a pitched roof with 200mm of loft insulation. The floors are solid and uninsulated. Non-PVC double glazing throughout of an unknown installation date. One open fireplace.
Features: Limited internal space and constrained location.
Use: Residential accommodation
Total internal floor area 103 m^2
Main heating fuel: Oil with radiators.
Primary energy use: 269 KWh / m^2 per year
Building emission rate: 70.22 $kgCO_2$ / m^2 per year
Pre-upgrade assessed energy rating: E 44 (Potential B 84)
Pre-upgrade assessed CO_2 rating: F 38 (potential C 78)
Background: Occupier considering challenge of decarbonised system and currently relies on an oil/solid fuel as the heating source.



3.17.1 The occupier is keen to move away from the use of oil and solid fuel as the main source of heating in this old cottage. An energy survey was undertaken in November 2022 to establish the current energy rating and make recommendations to decarbonize. The full set of recommendations included an upgrade of a dated boiler, internal and external wall insulation, floor insulation, and solar PV panels. At this time, the energy assessment recommended upgrading the boiler with a new condensing boiler rather than heat pumps or other technology and, while likely to be cheaper (energy report notes this may cost between £2,000 to £3,000 pounds), will not decarbonize this property. This is a known anomaly (for more detail see: https://www.elmhurstenergy.co.uk/blog/2022/07/04/why-does-my-epc-not-recommend-a-heat-pump/) with the model used to develop energy assessments and due to be rectified and brought closer in line with policy (The current assessment model used is called RdSAP 2012 and an update RdSAP v10.2 is being developed for release soon, see Standard Assessment Procedure - GOV.UK (www.gov.uk)).

3.17.2 The occupier noted that their property "leaks heat through the solid walls so easily" and that they were committed to decarbonisation: "I would love to reduce the carbon footprint for this building and in fact what we're doing at the moment is we are trying to reduce our usage of oil not just because of the financial element which is scary but it's also just on the environmental side and using sustainable wood for the solid fuel wood burner. We try to run the wood burner at the right temperature so it's not admitting as much carbon as it would otherwise do – also if it's (the wood) not seasoned properly."

3.17.3 The occupier was disappointed and did not really understand why heat pumps were not recommended: "I like the idea (of heat pumps) but you hear so many negative reports about them and that the costs are quite considerable. Also the fact that you would need a very energy efficient house to start off with so you'd have to have those extra costs of insulation and all the rest of things just for the air source heat pump to have some impact on the ambient air temperature. So that's that's a real consideration you know." Another consideration relating to insulation "even if we are able to afford to insulate inside up to the level required, it should be within the room we'd lose a lot of space as it's quite small cottage to start off with." The occupant was also not just concerned with the loss of space "it is the aesthetics of it as much as anything else: you live in a pretty place and then you then do things to it - although it's making it more thermally efficient - it actually is undermining the whole reason to live in the building, as far as I'm concerned, visually." Additionally, "We have solid slate floors so insulating the floor would be quite difficult and not something we would do as they are original."

3.17.4 Ultimately, the occupier noted the cost looked prohibitive: "We are living on a pension and to invest around "£30,000 for the heat pump and insulation is not going to happen."

3.17.5 The occupier had been researching using recycled cooking oil in the current system: "utilising kind of cooking oil to replace kind of oil but I don't know whether or not that would be acceptable anyway because wouldn't there be carbon emissions from that? Would Bio LPG be a cleaner option?" There was clearly little information about alternatives for them. "I have wondered about solar panels on the roof, and I think it would spoil the look of the property and I don't want to put aesthetics over environmental issues, but I think there are other ways that can then that it can be achieved."

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- It is unlikely that this occupier will move to the use of heat pumps given the cost and impact on space and building aesthetic and the use of BioLPG and bioliquids might provide a cost-effective low carbon solution.

3.18 Conclusions relating to rural households

- Decarbonisation tended to come forward on properties where the owners were able to access some funding toward elements or where they were renovating properties and could afford to do so. Only a limited number were contemplating decarbonisation – energy efficiency was the greater driver - and none were aware of off-grid boiler upgrade policy recommendations.
- Clearly homes that were contemplating or had heat pumps installed were facing more than the cost of installation to attain efficient systems and while there were some helpful reported benefits many were not able or keen to have heat pumps.
- There were several instances where solutions not included in RdSAP may be appropriate means for occupiers to decarbonise.
- Those that were eligible for funding took advantage of technology offered occasionally at the expense of a common-sense whole building approach. This resulted in significant disruption to occupants and many inefficient buildings.
- More financial help and guidance will be needed to help the majority achieve efficient and decarbonised off grid solutions to their heating and hot water needs.
- Only one of the dwellings that has been upgraded has achieved a rating of A and in this case the building already had filled cavity walls, double glazing, etc. and the occupier was able finance and undertake many of the works themselves.

4 The case studies: Commercial properties

4.1 E. Vehicle service garage converted into commercial office in a rural business park

Age: c.1980s
Construction: Block built with solid concrete floor.
Features: Large glazed former entrances to vehicles. Poor insulation or heating options.
Use: Commercial offices
Total internal floor area 125 m^2.
Main heating fuel: Dual Fuel Appliances (Mineral + Wood)
Building environment: Heating and natural ventilation
Primary energy use: 284 KWh / m^2 per year
Building emission rate: 23.97 $kgCO_2$ / m^2 per year
Assessed energy rating: B 49 (Benchmarks: newbuilt A 6, typical of stock A 23)
Background: Premises relies on solid fuel burner topped up with electric radiators and achieves a "B" rating.

4.1.1 A commercial office space has been made from a former vehicle service and MOT test site with large, glazed windows filling some of the wide entrances to the bays. The internal areas were carpeted, and the building had single block walls with no wall insulation or insulation to the roof space. The occupier had fitted a large wattage wood burner and they otherwise had some small electric radiators that they could use to top up when particularly cold. The measures identified included relatively low-cost insulation to roof void and, in this case, relatively easy to install exterior or interior wall insulation. There had not been any recommendation to move to a low carbon heating system such as a heat pump, which may be because there was no central heating system.

4.1.2 The tenant and landlord had a good relationship and while other (newer) buildings within the business park had air source heat pumps installed during construction, the findings of the energy performance assessment did nothing to encourage moving away from the use of solid fuel or to take any other efficiency measures. The current rating was "B" – and following assessment – this assessment was valid for a further 10 years.

4.1.3 The occupier, when presented with the assessment, noted "That's a surprise, and I have to ask, why would we do anything?". The occupier had discussed "greener measures" with the landlord, and they had agreed that the benefits did not cover the costs which would likely have to be passed to the tenant: "Why make the unit more expensive for a valued tenant?" The landlord had agreed to consider this further in the event that funding, or incentives became available.

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no short-term effect on this occupier (or landlord) as there was little incentive to upgrade to a low carbon source given the relatively high energy efficiency rating.

4.2 H. Stone barn converted into farm shop.

Age: Pre 1900
Construction: Stone granite walls and solid concrete floor.
Features: Local business selling turkeys and other local farm produce
Use: Commercial premises
Total internal floor area 24 m^2
Main heating fuel: Grid supplied electricity
Building environment: Heating and natural ventilation
Primary energy use: 586 KWh / m^2 per year
Building emission rate: 56.56 $kgCO_2$ / m^2 per year
Assessed energy rating: C 74 (Benchmarks: newbuilt A 5, typical of stock A 21)
Background: The barn had been tidied and wooden partitions put in and used an electric heater. The roof, floors and walls were uninsulated.

4.2.1 A commercial energy performance certificate was prepared and noted that the building achieved a "C" rating and while lower than new or comparable stock was impressive and partially because of the low extent of energy use. The low amount of energy used (which is factored in the commercial assessment) and the assumption made within the energy performance model that values mains electricity as a relatively low carbon source of energy may lead to a relatively good rating in this instance.

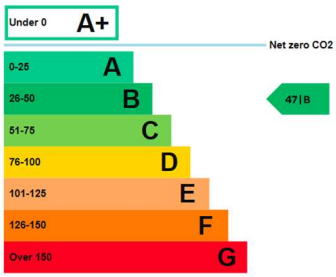
4.2.2 The occupant was astonished at the rating: "A 'C'! I can't believe it, I was dreading that it was going to come back with a requirement to raise the rating and spend lots on insulation and other things. How does this incentivise us doing anything to improve the efficiency or use renewables?"

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no short-term effect on this occupier (or landlord) as there was little incentive to upgrade to a low carbon source given the relatively high energy efficiency rating.

4.3 J. Filling station and shop converted to a commercial art gallery.

Age: c.1980s
Construction: Block cavity with stone facing. Solid concrete floors.
Features: Listed (Grade II) structure
Use: Commercial gallery
Total internal floor area 61 m^2
Main heating fuel: Grid supplied electricity
Building environment: Heating and natural ventilation
Primary energy use: 301 KWh / m^2 per year
Building emission rate: 28.77 $kgCO_2$ / m^2 per year
Assessed energy rating: B 47 (Benchmarks: newbuilt A 1, typical of stock A 3)
Background: Former fuel oil heating. Current electric heated and inefficient building assessed by a surveyor and included recommendations for insulation and heat pumps.



4.3.1 This former filling station and shop used to be heated with fuel oil heating and more recently fitted with electric heaters.

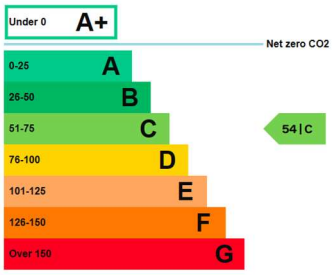
4.3.2 Whilst this business premises had moved away from fuel oil it was described by the occupant as" terribly energy inefficient, really". My bills are ridiculous, I open one day a week … throughout winter and it varies from about £1,000 and £3,000. That's just because it's a really inefficiently built building. This used to be the front part of a filling station where the shop and cash register were, and it has been dry lined but there is no central heating." "It is hard at the moment when it is winter and I am not selling much (the gallery is strongly dependent on tourist income) and have high bills but hopefully when the summer comes and I expect the bills to be very low in the summer … when the sun's out it actually warms up very quickly, it's got lovely light in there and it's got lots of solar gain. At the moment, I've got a little wood stove in there which somebody tells me 0.56p an hour to run and I have electric radiator when I need it to pump in a bit more heat." The occupant was in close discussion with the landlord and noted that rather than take on the very expensive recommendations and retrofit / better insulate they "might knock it down - so you know it's not really worth putting any money into it anyway". The occupier had "offered it to me as a lower rental opportunity and to see if could make a go of it with something 'glamorous' on the site". Yet the occupier noted that the landlord wanted to offer better premises "…it may work out that he wants to rebuild with very nice energy efficient new buildings, and I might end up taking one of those eventually or I might not". A lot of this investment hinged on stable income and the occupier noted "It might all workout fine, so suddenly, it could get a lot of passing trade and … the summer might be amazing, and we can develop efficient space or not". "We opened in November 2022 when we were anticipating a crash and energy bills have rocketed and everybody is saving money in the cost-of-living crisis – hopefully we've been through the worst of it."

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no short-term effect on this occupier (or landlord) as relied on mains electric heaters.

4.4 N. Rural village public house

Age: Pre 1900
Construction: Stone walls (granite, uninsulated) with solid slate flag floors. Slate pitched roof.
Features: No central heating, relies on wood fires and bottled gas.
Use: Commercial accommodation
Total internal floor area 322 m^2
Main heating fuel: LPG (bottle)
Building environment: Heating and natural ventilation
Primary energy use: 391 KWh / m^2 per year
Building emission rate: 65.71 $kgCO_2$ / m^2 per year
Assessed energy rating: C 54 (Benchmarks: newbuilt B 26, typical of stock E 106)
Background: A commercial energy performance certificate prepared for the public house which includes a number of restaurant areas.



4.4.1 The commercial energy performance certificate rated the property as “C 54” and compared favourably with the typical rating for such stock of “E”. An LPG bottle was used for some fires but otherwise the main areas were heated (when open) by solid fuel (wood) fires and electric heaters. The roof was poorly insulated along with poor insulated floors and walls. Key recommendations made in the recommendations report included switching from LPG to a bio-alternative such as BioLPG or Biomass which was considered to have a high potential impact and change that would pay for itself within three to seven years.

4.4.2 The Landlord of the pub was "really surprised about the rating, although I suppose we don't use a lot of energy through the week." The Landlord was asked if they would look to undertake the recommendations or look to further decarbonise energy and heating "we wouldn't, but I can pass the report over to the owner although I can't imagine they will do anything unless they really have to." The Landlord was "I would be worried anyway if we had to shut at a busy time of the year to do anything as would be a loss of income to us and I am not sure if we would be able to recover that if the owner thought it would benefit us in energy savings". In terms of other works the Landlord noted "I can't see that we would want to do anything that changes how the building looks as it is a pretty pub so putting insulation on the outside or inside of the walls would look awful and might put punters off".

Potential impact on occupiers if the replacement (gas) boiler ban is in-acted as currently proposed:

- The replacement boiler ban would have no short-term effect on this occupier (or landlord) as there was little incentive to upgrade to a low carbon source given the relatively high energy efficiency rating. In this case the use of BioLPG and bioliquids might provide a cost-effective low carbon solution to comply with regulation should it come in.

4.5 Conclusions relating to rural commercial premises

- The current appraisal process provided little incentive for commercial occupiers or owners to decarbonise given the findings of non-domestic energy assessment. Properties assessed performed well if they had mains electric heating – the assessment model considers this to be a low carbon source of energy given the UK mix which includes renewables and nuclear power – even if the buildings were relatively inefficient.

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