THE HANDIHEAT PROJECT

Low-carbon technology and rural energy poverty: A review of policy and practice in the NPA and EU

Abstract

The decarbonisation of domestic energy consumption in rural areas is a critical challenge for meeting carbon reduction targets in the Northern Periphery and Arctic (NPA) region and the wider EU. Simultaneously, there is a growing recognition of the need to tackle rural energy poverty, with recent estimates suggesting that as many as 1 in 5 rural households in the EU may be living in energy poverty.

This report was prepared by National Energy Action (NEA), the UK's national fuel poverty charity, for the HANDIHEAT project. It reviews policy and practice from across the NPA and EU with the aim of identifying approaches and barriers to tackling energy poverty with low-carbon technology (LCT) across the NPA region, and of assessing policy initiatives that will enable countries in the NPA region to address energy vulnerability and energy poverty in rural, remote, and island communities.

Authors: Dr Danielle Butler and Dr Matthew Scott, NEA

HANDIHEAT

Northern Periphery and Arctic Programme 2014-2020

EUROPEAN UNION

Investing in your future
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1. Introduction

1.1. HANDIHEAT

HANDIHEAT is a €2m funded project led by the Northern Ireland Housing Executive (NIHE). It is supported by the Northern Periphery and Arctic Programme (NPA) and the EU European Regional Development Fund (ERDF) to support research that will address fuel poverty, identify renewable energy solutions and improve energy efficiency in rural homes across Northern Europe. The aims of the programme are:

- To document current home energy policy and practice across Northern Europe
- To develop viable business models with innovative solutions to tackle energy problems in rural areas
- To identify opportunities for rural communities to access renewable energy sources and reduce their reliance on fossil fuels

The overall objective of HANDIHEAT is to develop a set of resources, implementation toolkits, decision making guides and a roadmap for the rural community housing sector. Pilots will provide an evidence base and guide to what can be achieved, and resources will be produced for government policy makers on sustainable energy solutions for rural communities. The intended outcome of HANDIHEAT is a set of sustainable solutions that will protect rural communities from energy price fluctuations and improve the social wellbeing and quality of living throughout NPA regions.

1.2. This report

This report presents the findings of a programme of research designed to support the aims of HANDIHEAT. The aim of the research was to conduct a policy review of approaches and barriers to tackling fuel poverty across the NPA region and the wider EU, and to identify and assess policy initiatives that will enable countries in the NPA region to address energy vulnerability and energy poverty across rural, remote, and island areas.

The research detailed in this report has involved the following activities. A full description of the first three activities can be found in Annex One.

- **A desktop review** of the evidence to identify a range of policies and practical delivery models that address fuel poverty, energy efficiency and low carbon energy solutions, particularly in rural and remote communities, across Europe.[1]
- **A Europe-wide Call for Evidence (CfE)** to explore some of the issues identified in the review in more detail and gather views on EU, member state, and NPA member countries' current practice, policies and areas under development, or in need of further development.
- **Ten in-depth interviews with key actors and stakeholders** to identify and explore policy enablers in each NPA region, policy successes, policy challenges and policy gaps. Across these interviews, 17 experts in total were spoken to (see Annex One).
- **A synthesis and gap analysis,** which has integrated data from the above three activities into a European comparative policy matrix, which identifies a range of energy poverty, energy efficiency and renewable energy relevant policies and practices and their key features. Three case studies have been developed as part of this, which are integrated within the main text of the report.

The report is set out across multiple sections that respectively cover the following:

- Framing and definitions of fuel poverty and energy poverty (Section 2)
- Opportunities (Section 3) and barriers (Section 4) for linking low carbon technology with efforts to tackle energy poverty in rural and remote settings
- Key lessons from case studies and policy contexts (Section 5)
- Conclusions and summary of key findings (Section 6)
- Details of CfE respondents and interviewees (Annex One)
- Comparative policy matrix (Annex Two)

1.3. A note on terminology

Fuel poverty is a term that is mostly used within the UK. In the wider NPA and EU, energy poverty is in wider usage. Although there are differences and nuances between how these terms are used, as discussed in Section 2 below, they are sometimes used interchangeably depending on the context.

From this point onwards, we use the term fuel poverty only in reference to specific UK definitions and policies discussed in Section 2, and in cases where we quote it directly from interviews, CfE responses, and broader evidence. In all other cases, we use the term energy poverty, to reflect the intended NPA and EU-wide scope of this work.

2. Framing and defining energy poverty in the NPA and beyond

This section considers the ways in which fuel poverty, energy poverty, and vulnerability are understood and defined across the NPA and wider EU. It draws particularly on the rapid evidence review, which identified and analysed specific definitions of fuel poverty used by national and supranational governments, and on the CfE and expert interview findings to understand how these definitions are used in practice.

2.1. The devolved nations of the UK

Historically, the devolved nations of the UK have the most developed fuel poverty definitions and policies, and so will be considered first. In the UK, fuel poverty has been broadly defined as the inability to achieve the levels of warmth required to meet energy needs and maintain good health and wellbeing. It is widely understood in the UK as resulting from the interaction of three key drivers: low household income, high energy prices, and the energy inefficiency of the housing stock. In the early 1990s, a definition of fuel poverty was offered by Boardman which became largely accepted in policy, whereby a household is considered to be experiencing fuel poverty if needing to spend more than 10% of their income on energy costs.[2] However, in the intervening years this definition has been both nuanced and diverged from in the different UK nations.

In England, the 10% indicator was replaced following the 2012 Hills Review, which recommended a new definition of 'Low Income High Costs' (LIHC). In this definition, a household was considered fuel poor if:

- They have required fuel costs that are above the median level, and;
- Were they to spend that amount they would be left with a residual income below the official poverty line.

In addition, the Hills Review recommended the creation of a secondary indicator defined as the 'fuel poverty gap'. This indicator estimates the amount by which the assessed energy needs of fuel poor households exceed the threshold for reasonable costs. In other words, this indicator was intended to measure the amount by which energy costs would need to drop, or income would need to rise, for a household to be lifted out of fuel poverty, and was thus a measurement of the severity and depth of fuel poverty.[3] However, it should be noted that this definition was criticised, especially its reliance on the median income level, which belied an acceptance that not all fuel poverty could be alleviated and arguably underplayed the role of the energy market in generating fuel poverty.[4]

The LIHC definition was only adopted in England, and has recently been replaced by a newer definition: 'Low Income Low Energy Efficiency' (LILEE). This definition considers a household to be fuel poor if:

- It is living in a property with an energy efficiency rating below Band C in England's Fuel Poverty Energy Efficiency Rating (FPEER) methodology, and;
- Its disposable income (after housing costs and energy needs) would be below the poverty line.[5]

Divergent or traditional definitions have been adopted in Scotland, Wales, and Northern Ireland. In Wales and Northern Ireland, households needing to pay more than 10% of their household income to meet energy needs and maintain a satisfactory heating regime, broadly defined as 21°c in the living room and 18°c in other rooms, are defined as being in fuel poverty.[6] Furthermore, the Welsh

definition also includes definitions of severe fuel poverty, at risk of fuel poverty, and persistent fuel poverty, as shown in Table 2.1. below.[7] The purpose of these additional markers is to enable the measurement of shifts in fuel poverty across time, the severity or depth of fuel poverty, and the number of households not fuel poor but at risk of being so in the future. Research in Northern Ireland also discussed the possibility of incorporating an area-based severity index into fuel poverty definitions, defined as "*a more equitable assessment of how regional efforts are altering the fuel poverty landscape",* and recommended "*that the twice-median threshold of 10% is augmented with additional points on the scale ranging from 2.5X to +4X median*."[8]

Definitional aspect	Explanation
Severe fuel poverty	Households needing to pay more than 20% of their full household income to maintain a satisfactory heating regime.
At risk of fuel poverty	Households needing to pay more than 8%, but less than 10% of their full household income to maintain a satisfactory heating regime.
Persistent fuel poverty	Households needing to pay more than 10% of their full household income to maintain a satisfactory heating regime in two out of the three preceding years

Table 2.1. Definitional aspects of fuel poverty in Wales

Finally, in Scotland, the 10% definition is also utilised, but with subtle changes. In Scotland, a household is considered fuel poor if:

- After housing costs have been deducted, more than 10% (20% for extreme fuel poverty) of their net income is required to pay for their reasonable fuel needs; and
- After further adjustments are made to deduct childcare costs and any benefits received for a disability or care need, their remaining income is insufficient to maintain an acceptable standard of living, defined as being at least 90% of the UK Minimum Income Standard (MIS).[9]

Across these definitions, there is an acceptance that fuel poverty is primarily shaped by household income levels, which are nonetheless rendered slightly differently in each case; Scotland's definition, for example, includes explicit adjustment based on childcare and/or care costs. Energy prices and the energy efficiency of domestic properties are also included, although typically implicitly, in the stated definitions, and are often only addressed in full in the detailed energy modelling methodologies each definition relies on.

2.2. Beyond fuel poverty: energy poverty and vulnerability in the Netherlands and EU

There is limited evidence that energy poverty has received formal definitions in EU and NPA countries outside of the UK.[10] As noted, fuel poverty has a much longer history of measurement and definition in the UK, and outside of the UK, fuel poverty is typically understood as energy poverty. The research has identified proposals for two definitions that are reviewed in this sub-section: one at national level in the Netherlands, and one at supranational level in the EU. These proposals are noteworthy for offering an expanded, multifaceted set of energy poverty indicators.

In the Netherlands, there is evidence that the 10% definition is seen as insufficient for developing an adequate definition of energy poverty. One study uses two complimentary indicators; a) the 10% indicator, and b) 'payment risk', which is defined as a household that does not have sufficient budget for living expenses after paying for housing and energy costs. Based on these indicators, 269,000 (approximately 3.5%) households in the Netherlands are in energy poverty. However, more recent research considers energy poverty as a more multidimensional and complex issue, often also involving the underconsumption of energy, the inability to access energy-saving and/or sustainable technology, and wider connections between debt, ill-health, and financial vulnerability. Recommendations are made for the introduction of a multi-indicator measuring instrument, "*charting progression according to several indicators*" which identify and measure both the causes and effects of energy poverty. It suggests including housing (energy efficiency rating, room temperature, and access to services), health (physical, mental, and social), and affordability (high energy expenses, due payment, and debts) within this multi-indicator framework. Importantly, the research also recommends departing from using only quantitative methods in measuring energy poverty, and instead using a combination of qualitative and quantitative methods to improve "*knowledge of the dynamics of energy poverty by providing insight into how people deal with it, the considerations they take into account and how different policies affect their lives*."[11]

At the supranational EU level, the Energy Poverty Observatory (EPOV), established and initially led by UK academics with significant support and input from policymakers, practitioners, and academics from across the EU, has attempted to develop an approach and set of indicators to measure energy poverty. Similar to the approach presented in the Netherlands, EPOV defines energy poverty as "*a culturally sensitive, multi-dimensional concept that varies over time and by place and is thus not easily captured by a single indicator*." The EPOV proposes an approach to measuring energy poverty which is based on *consensual* indicators (those based on self-reported assessments of indoor housing conditions and access to basic energy services) and *expenditure-based* indicators (which compare energy costs to absolute or relative thresholds, as per the 10% definition). From this, they develop a set of primary indicators, two of which are consensual and two of which are expenditure based. Consensually, a) the ability to keep a home adequately warm and b) arrears on bills are included. In terms of expenditure, a) absolute (equivalised) energy expenditure below half the national median and b) share of (equivalised) energy expenditure (compared to equivalised disposable income) above twice the national median are used. In addition, they list a wide range of secondary indicators, relating to energy prices, building stock quality, poverty and health risks, and other consensual and expenditure based indicators (e.g., presence of damp, rot, or leak in a home). This dual approach, comprised of primary and secondary indicators, is not intended as a final energy poverty definition for the EU, but can "*be used to give a snapshot of energy poverty issues, which can then be explored in more detail in research and action projects*."[12] However, as part of the EU Clean Energy Package, member states will be required to define, measure and periodically report on energy poverty levels, as well as including policy measures in their long term renovation strategies aimed at alleviating energy poverty.[13]

These two developments in the Netherlands and EU more widely define energy poverty much more comprehensively than in the UK, and attempt to develop a suite of indicators to measure its severity, longevity, and scale. This was a theme discussed by some of the expert interviewees as part of this research, whereby the limitations of a definition based on a narrow range of indicators (as in the UK) were recognised. One interviewee, for example, provided a further example of energy poverty in Estonia, noting how "*they will very much specifically talk about all of the energy services a household needs and not just the heating element*", and that defining energy poverty was more broadly evolving away from the previously accepted 10% definition. Other interviewees, especially those

working in academia, discussed their preference for broader definitions. One, for instance, discussed the possibility of incorporating unequal access to transport into conceptualisations of rural energy poverty or disposable income:

> "*One of the things I noticed with the [10%] measure as well is for rural people it doesn't really capture rural life, and it doesn't capture their financial constraints and just the way that you have to live in rural places and means that you are not always recognised as fuel poor when you actually are fuel poor. One of the things that I think is starting to get picked up more in the literature now is things like transport poverty, where that isn't counted. It's not calculated in the living costs and that type of thing. It doesn't count basically, but it's a fundamental cost that you need if you are living miles away from everything. You need to have a car. You need to be able to travel to places, and having that extra financial strain on top of perhaps really seasonal jobs or unreliable income and higher costs for your energy just really, it all multiplies and compounds the issue*."

Moreover, other interviewees preferred to disregard the term fuel/energy poverty altogether in favour of other, more dynamic concepts, such as energy vulnerability. For example,

> *"I haven't really ever explicitly used the term rural fuel poverty because I think the South Wales Valleys come under a sort of strange, different classification, don't they? They are not urban or rural. We've done some work around the concept of energy vulnerability instead of fuel poverty because of criticisms that fuel poverty is this static thing that you are either in or out of, whereas energy vulnerability is a bit more dynamic and recognises that things change as people's circumstances change."*

The view that energy poverty, or vulnerability to it, is complex and multidimensional was also reinforced in academic literature,[14] and in CfE responses from frontline organisations and charities who support energy poor households. Respondents similarly linked energy poverty and vulnerability to insufficient heating and wider energy services, low incomes, health, problems with debt and state benefits, and housing that was difficult to keep warm or well ventilated. Furthermore, some respondents to the CfE noted that while the UK 10% definition was accepted in theory, it was considered to be narrow and often difficult to apply in practice, and consequently not used in the targeting of support and advice to households. Indeed, for one respondent, it was "*the least-worst definition used in practice*." As such, respondents from frontline organisations or charities highlighted that the rigid criteria typically used in the UK was less important than the more holistic goal of reaching as many people as possible, whether through the provision of energy efficiency advice, or support with specific assistance schemes administered by energy suppliers or government. In other words, while such rigid definitions and approaches to measuring energy poverty may be helpful with monitoring progress against policy objectives, they are also understood as challenging at the delivery level.

Other respondents highlighted the challenges of reaching those in need of support in rural communities, whereby energy poor households might be 'hidden' in wealthier communities – "*like finding a needle in a haystack*" – or considered asset-rich based on the value of their properties but 'cash poor' in reality, rendering them unable to invest in low-carbon technology (LCT) or other measures. The broad point that all of these respondents highlighted was that while definitions and measurements are necessary, they are not typically used in practice, with support targeted wherever and however it was needed, for instance on the basis of proxies based on more easily observable risk factors, such as affordability, health, and other aspects of vulnerability.

However, other expert interviewees complicated these definitions further by drawing comparisons between different kinds of governance among NPA and EU member states and questioning the utility of definitions of energy poverty within their own national contexts. For example, expert interviewees from Finland suggested that their specific context rendered energy poverty less pressing than other social issues (such as access to food, homelessness, etc.), and suggested that the historical presence of a strong social security system in their country might make the depth and severity of poverty, including energy poverty, less acute than in the UK. Further, interviewees also noted that in Finland, "*it's not that uncommon that you are poor, but still you are going to somehow get your house heated in most cases […] there's social services and it's really, really rare that you are freezing in your house because you don't have any electricity*."[15] Put differently, the point these interviewees made was that if energy poverty is at least partially defined by a low household income relative to high energy expenditure, the social security arrangements in their country rendered this less of a problem than it may be elsewhere, especially compared to the UK. This testimony is supported by available information on energy poverty definitions and strategies in other NPA countries, as summarised in Table 2.2. below. Evidence suggests, for example, that energy poverty is not considered as much of a social policy priority in Norway,[16] Sweden,[17] or Denmark,[18] with no discrete national definitions or strategies to address energy poverty identifiable.

NPA country	Energy poverty definition	Energy poverty strategy	Role of rurality in definition/strategy
Finland	None identified.	None identified.	None identified.
Ireland	A household that spends more than 10% of their income on energy is considered to be in energy poverty.	A Strategy to Combat Energy Poverty, 2016-2019[19]	None identified.
Sweden	None identified.	None identified.	None identified.
Scotland	A household that spends more than 10% of their income (after several deductions, see above) on energy is considered to be in fuel poverty	The Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019[20]	Acknowledges key links between rurality and fuel poverty, with adjusted definition of rural fuel poverty.
Northern Ireland	A household that spends more than 10% of their income (after several deductions, see above) on energy is considered to be in fuel poverty	A New Fuel Poverty Strategy for Northern Ireland 2011[21]	Northern Ireland is 40% rural, therefore rural heating needs are greater heat needs are greater because of latitude and climate and because of the higher proportion of rural households.
Greenland	None identified.	None identified.	None identified.

Faroe Islands	None identified.	None identified.	None identified.
Iceland	None identified.	None identified.	None identified.
Norway	None identified.	None identified.	None identified.

Table 2.2. Formal definitions of fuel poverty or energy poverty in NPA countries

2.3. Rurality and rural energy poverty

Finally, the evidence suggests that all attempts at measurement and definition in rural, remote, and island areas are complicated by the specific characteristics of rurality and remoteness. Energy poverty is typically more pronounced under present definitions in areas defined as rural or sparsely populated. In Northern Ireland, for example, 31.6% of all households in rural areas were in fuel poverty in 2016, compared to 22% of the total population.[22] In the Western Isles of Scotland, the situation is even more pronounced, with an estimated 55% of island households living in fuel poverty, compared to 31% for the whole of the country.[23]

In addition, data from the aforementioned EPOV indicators show that households located in sparsely populated rural areas are more severely affected by higher rates of energy expenditure, with a proportion of 21.1%, compared to 16.5% and 13.6% for areas defined as intermediate and densely populated, respectively.[24] Scotland's 2016 plan for delivering warmth in rural Scotland listed 21 distinctively rural dimensions of fuel poverty, including colder and more severe weather types, harder-to-heat housing types, more limited mains gas coverage, incumbent supplier dominance of rural energy markets, and a reliance on alternative and typically more expensive heating fuels.[25] While many of the issues specific to Scotland are not applicable across the broader NPA region, evidence and expert interviews as part of this research have determined several characteristics of rural energy poverty that are common to most or all NPA countries. Table 2.3. below summarises these characteristics.

Dimension of rural energy poverty in NPA countries	Explanation
Lower income relative to urban areas	Rural areas are typically characterised by below average household income, and they tend to require higher incomes to reach minimum income and living standards due to additional travel, heating, electricity, and food costs.
Connectivity	Rural areas face multiple connectivity challenges, specifically with regards to digital connectivity (e.g., internet, telephone), transport connectivity (e.g., less frequent public transport services, higher travel costs), and social connectivity (e.g., smaller social support networks). This can increase essential living costs, leading to a smaller proportion of household income which can be spent on heating.
Accessibility of services	Essential LCT and energy poverty support services are more difficult to access in rural areas (e.g., unavailability of local installers and advice services). Furthermore, energy advice and support services can find it harder to connect with the most vulnerable households in rural areas. This also extends

	to broader essential services (e.g., banking and postal services).
Housing stock quality	Homes in rural areas tend to be older, harder to treat buildings, which therefore require extensive insulation and remedial work to be installed in addition to a new heating system to have the greatest impact on energy poverty. This increases the total cost of the measures and reduces the possibility of their installation.
Socio-demographics	Rural areas tend to be characterised by above average levels of older people, who may have higher energy needs and may face specific barriers to accessing warmth, such as disability, ill-health, low income, and digital/social exclusion.
Extreme weather	Rural areas, especially in the NPA, are characterised by extremely cold weather systems. Greater exposure to cold, wind and rain make houses more prone to rapid heat loss and serious fabric defects.

Table 2.3. The characteristics of rural energy poverty in the NPA

As a result of these rural specificities, some evidence suggests that definitions may need to be modified or rewritten entirely to properly capture their extent and consequences. For example, Scotland is the only nation in the EU the research was able to identify with a specific definition of rural fuel poverty. In Scotland's 2019 Fuel Poverty Act and definition, households in remote rural areas, remote small towns, and island areas have an additional weight applied to their income when determining whether or not it is in fuel poverty.[26] One expert interviewee was part of the coalition of academics and practitioners that successfully argued for this adjustment, and informed us that the cost of living in rural areas, more limited access to energy services and transport services, poorer housing stock, and the specific ways Scotland is divided administratively and geographically meant that an adjustment was necessary to capture the extent of fuel poverty in Scottish rural areas. Beyond this, the research has not uncovered evidence of any other definitions or planned definitions that have specific rural adjustments, but it is clear that the characteristics of rural areas, as summarised in Table 2.3., exacerbate and complicate energy poverty across the NPA.

However, it should lastly be noted that the evidence suggests rural energy poverty should not be homogenised. Interviewees highlighted that although the causes and consequences of rural energy poverty are often distinct, there are differences across a) rural, remote, and island communities, and b) within individual countries, which are typically the result of the complex interrelation between geographical, economic, historical, and political factors. It became clear across the interviews that while broad commonalities exist, remote communities in the northernmost reaches of Finland cannot be easily compared to the rural valleys of Wales, the 'fragile communities' of Iceland, or the sparsely populated island of Nólsoy in the Faroe Islands. This was encapsulated by two interviewees, the first of whom told us that:

> "*I think you'd think, within one small community, that everybody will be homogeneous, and you can say, "Oh, that community will fit into that segment," but that's not the case [as] it's made up of so many different individuals. That needs to be taken into account*."

While the second noted:

"*Well, people who live in the countryside are just as diverse as people in urban settings, and just because you can't see it doesn't mean it isn't there*."

As a result, the commonalities presented in Table 2.3. above should be considered a starting point for understanding the specificities of rural energy poverty and not a definitive framework that can be applied to specific cases without further empirical investigation.

3. Opportunities for linking low-carbon technology and energy poverty

This section moves on to consider successful programmes, projects, or approaches using LCT to address energy poverty in rural, remote, and island communities. It uses evidence drawn from current practices and examples, as well as proposed approaches that are not yet widespread but have potential to make firmer links between LCT deployment and rural energy poverty. The following four sections explore key opportunities for linking these two areas more effectively and efficiently, focusing on technologies, the role of holistic support, community energy, and other approaches and models.

3.1. Technologies for low-carbon heating and energy poverty

This first subsection considers the different LCTs that may contribute to the alleviation of energy poverty in rural, remote, and island areas. It does not include all technologies that were uncovered in the research, such as hydro and geothermal, and covers only those that were reviewed across multiple strands of the research.

Heat pumps

Much of the evidence considered in this research centres on heat pumps as one of the primary technologies to decarbonise domestic heat in rural and remote areas. The evidence suggests that Nordic NPA countries and Iceland have been particularly successful at heat pump deployment in both domestic and non-domestic rural settings. Interviewees from these countries told us, for example, that "*heat pumps [were] installed [in] new houses that municipalities built, and that is what people have been doing when they've been renewing or renovating their houses, they've been putting [in] heat pumps*." Another interviewee discussed how heat pumps were increasingly replacing oil in rural areas in Finland, and that different kinds of heat pump (air-to-air, air-to-water, and ground source) were being deployed in equal measure.

However, a number of challenges or hurdles to heat pump deployment were discussed by interviewees, especially with respect to their role in benefitting energy poor households. One interviewee discussed cases of where undersized heat pumps have been installed in rural households in Scotland because of perceived limitations of Energy Performance Certificates (EPCs) in modelling building conditions accurately; "*people then use other forms of heating, and you don't get the energy savings that have been predicted*." Some interviewees discussed the capital cost of installing heat pumps as prohibitive for energy poor households, and described anecdotal situations where heat pumps had been installed in energy inefficient social housing, leading to higher energy bills; "*it's just cost them an absolute fortune to keep the heat pump running basically*." Correspondingly, one interviewee noted that heat pumps might be better suited for new build properties, and that other technologies such as solar PV might be the optimal options for decarbonising older rural housing stock. Finally, there was a suggestion in one interview that heat pumps may have certain limitations related to cultural norms and practices:

> *"if you have a cold area and you add heat pumps […] that significantly reduces costs and gets you closer to what you are experiencing, the cost, in geothermal. The main difference is, even though you take this route, you don't have this endless supply of warm water, so you still don't have quite the luxury that the geothermal provides you with, but you still have the cost, maybe, down to a reasonable level compared to geothermal areas."*

Put differently, in Iceland transitioning to a heat pump instead of to the limitless hot water of geothermal may be problematic for broader reasons linked to cultural norms and expectations,

although it should be noted this was a specific example that may not be more broadly representative of the wider NPA.

Solar PV and solar thermal

Solar PV and solar thermal technologies were also discussed by interviewees as a means of decarbonising domestic heat and power. Solar PV refers to the installation of solar panels to generate electricity, which is then used in the household. Solar thermal refers to the installation of solar panels which use the energy of the sun to directly heat hot water. The technologies are therefore related yet distinct. With respect to solar PV, interviewees discussed examples of how it could benefit energy poor households. One interviewee described a solar PV project that included battery storage and dynamic pricing: "*they were encouraging people to charge their batteries overnight when the electricity prices were really low and then selling their [solar PV generated] excess into the grid when they could make more of a profit [from] it*." The dual benefit of this approach was lower energy bills and small profits from the sale of excess electricity to the grid, potentially alleviating energy poverty. With respect to solar thermal, another interviewee told us that while solar thermal is unlikely to meet 100% of the demand required for constant hot water, achieving up to 70% of this demand would cover a significant proportion of the cost required to do so. In sum, solar PV and solar thermal can offer the benefits of household level electricity generation, which can be used directly in the home or sold to the grid for small profits. This has the effect of reducing energy bills and generating small increases in income, which together can alleviate energy poverty.

However, as with heat pump technology, there were a number of challenges identified with the deployment of solar PV and solar thermal for energy poor homes. The high capital cost of solar panels, whether for PV or thermal, was raised by different interviewees as an issue for low-income homes. As one interviewee told us:

> "*The preliminary findings from our research into consumers were that they would be interested [in solar] if they didn't have to pay for it. So, affordability is a massive issue [and] you need to look at those with the low-incomes because they wouldn't really be incentivised to just go off and save up for a solar panel*."

Furthermore, there were questions raised by interviewees about the suitability of solar panels in northernmost and mountainous regions of the NPA:

> "*You asked about solar panelling. It's not very common in Iceland as a source, and the primary reason being we have sun 24 hours a day during the high summer, but many of our communities are in fjords with high mountains, and, for example, on my farm, I don't have direct sunshine to the roof of my house from the middle of October until the beginning of February. So, it wouldn't be economical to have solar panelling*."

Summarily, while solar PV and solar thermal may be suitable in some parts of the NPA with consistent direct sunlight, there are challenges regarding how low-income rural households can be supported to access their benefits.

District heating

Whereas heat pumps and solar technologies can deliver heat and power through household scale electricity generation, district heating networks are defined as a system that transports heat to domestic and non-domestic properties from a central production plant. The evidence suggests that while district heating networks are common in urban areas, they can (and do) play a role in providing

low-carbon heat to rural areas; one interviewee, for example, told us that "*your ideal community for district heating is a small to medium rural community […] groups of a few hundred houses, that sort of semi-rural or rural community*", while a second concurred that they were feasible in semi-rural settings where houses are not located at significant distances from each other. A separate interviewee gave an example of a 1MW plant distributing heat to larger non-domestic facilities in a village: "*it's a village of something like 5,000 people and they heat the municipal buildings, fire department, school, so basically the big energy users, but not too many private [households] because you have certain heat losses*."

Interviewees cited locally available biomass, forestry waste, wood chippings, and other similar waste products as suitable for the development of district heating networks in rural areas. However, while there is some evidence that district heating networks "*can offer reduced fuel bills compared to alternative heating systems*",[27] the research has not identified evidence strongly linking them to the alleviation of energy poverty in rural areas.

Biogas and biomass

Biogas, biomass, and other forms of biofuel were discussed by interviewees as important technologies for decarbonising rural homes. At its broadest, biomass refers to all carbon-based materials, including plants and animals, but was discussed by interviewees primarily in terms of agricultural waste (e.g., livestock manure), forest residue (e.g., wood), and other rural organic matter.[28] Biomass can be burned directly for heat and power or transformed through anaerobic processes into biogas or other kinds of biofuel. Biomass and biogas can be used in district heating schemes, as noted in the previous subsection, and can also be used at the household scale in rural areas. For example, one interviewee from Finland discussed a biogas pilot in North Karelia, close to the Russian border:

> *"Basically, this is a border crossing to Russia from here, and the pilot site we are running is in this community in here, or this small area of houses. So, these are like community-owned row houses where they are offering for rent for really reasonable prices. And there is an old fire station here, and that kind of stuff, and old farmhouses here. And this is the actual site where our [compressed biogas] heating unit is located. So, it's serving these few row houses with, I think it's, like, 19 apartments, or something like that – maybe the other guys can correct me if I'm wrong. So, basically, we are heating these community-owned social housing units in this region, and it's a really good site because it was heated with oil before we came in, so we are replacing heating oil in this pilot. And this is as remote as it gets, basically, in Finland, because no-one drives by this road, basically, because there's nothing around it."*

Other evidence suggests that household scale biomass boilers are an option for decarbonising "*hard-to-insulate rural properties where heat pumps are not viable*."[29] The evidence suggests that biogas and biomass may also be more effective in rural areas with a large amount of suitable material resources, such as in northern Scandinavia, where forest energy is abundant.

Hydrogen

Finally, there is evidence that hydrogen may become an option for decarbonising heating in some rural homes in the next two decades. Some NPA and EU countries with extensive gas networks are currently exploring whether the existing gas network could be repurposed to transport hydrogen, which emits only water when burned in the home. With regards to rural households, clearly many rural households, especially those which are remote and/or island households, are not connected to gas in NPA and EU states with gas grids, but one estimate suggests there may be as many as

89million rural households connected to gas across Europe.[30] Accordingly, some rural households that are connected to the gas grid could be decarbonised this way in the medium- to long-term.

There is currently limited evidence on the extent to which hydrogen may offer a partial solution to energy poverty in rural homes with gas grid connections, with its costs and benefits still contested.[31] One interviewee suggested that as renewable electricity generated from offshore wind plummets in price, the cost of producing zero-carbon hydrogen may also plummet. A second interviewee, however, testified that hydrogen should not be used for domestic homes, whether urban or rural, because it is not cost-effective to do so, and that its use should instead be concentrated in industrial processes, energy storage, and hard-to-electrify sectors (such as steel). Despite this, there is some evidence that island communities may benefit from hydrogen production in other ways. For example, the Orkney Islands in Scotland have an overabundance of renewable wind electricity, which cannot be transported to the local electricity grid and is therefore sometimes lost.[32] There is a possibility therefore that Orkney, and other NPA island communities with large wind power capacity such as the Faroe Islands, could produce hydrogen from excess renewable generation. This could be used for heat and power at peak load times, which is significant for contained and sometimes constrained island electricity grids, and could form the basis of economic activity, creating jobs and thus reducing energy poverty.

Summary

Ultimately, all of the LCTs identified in this research offer opportunities for decarbonising heat in rural areas, but there is limited evidence that each technology in isolation can alleviate rural energy poverty. Challenges were highlighted for each, and the evidence does not support the notion of one LCT as a silver bullet for tackling energy poverty and contributing to decarbonisation agendas. Instead, the evidence suggests that the most successful pathway to addressing rural energy poverty with LCT lies at the intersection of different technologies, advice and support services, and remedial forms of home improvement. This can be referred to as a *holistic energy poverty* offering, and it is to an exploration of this notion that the report now turns.

3.2. Holistic provision: mixing approaches, technologies, advice, and remedial measures

> "*Low carbon heat cannot be a solution in its own right and needs to be part of an integrated agenda to tackle fuel poverty and wider poverty issues*."[33]

At its broadest, the holistic energy poverty offer can be defined as one that combines the installation of LCT with other, related approaches to maximise the positive impact on energy poverty in rural areas. This subsection considers the two primary themes in the evidence: a) the provision of in-depth advice and support to rural energy poor households, and b) the installation of remedial measures, especially insulation, but also measures to improve air flow and address mould and damp issues. Together with the installation of LCT, these constitute the holistic energy poverty offering, as shown in Figure 3.1. below.

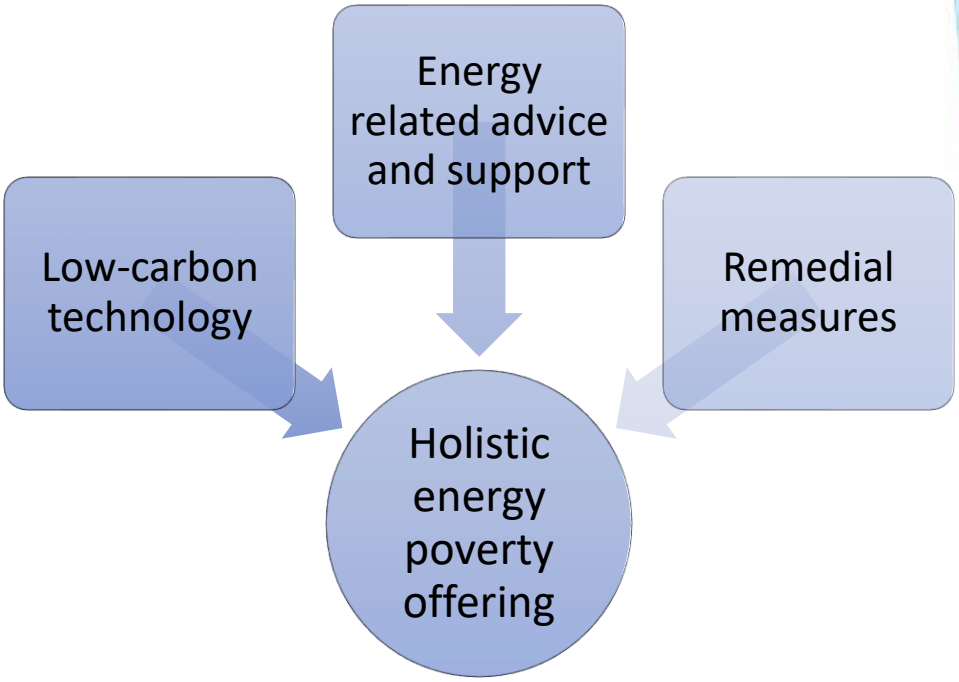

Figure 3.1. The holistic energy poverty offering

Having discussed different types of LCT in the previous subsection, this subsection tackles the other two elements of the *holistic energy poverty offering* sequentially.

Advice and support

The benefits of adopting a holistic approach relate not only to improvements in the energy performance of a property (i.e., approaches that combat heat loss or improve heating systems), but are also deeply impactful at the household level (in terms of health and wellbeing, for example). As one interviewee explained, at the core of work in this area must be a focus on people, and on:

> *"treating people as people, and not statistics. This person-centred approach, this holistic approach. If somebody [contacts a support service] for energy efficiency, and it turns out they've got a whole load of other problems that are much more significant, […] tackling those problems will often be much more beneficial than sticking 100mm insulation in their roof. You may well end up doing that as well, but dealing with poverty, social vulnerability, all the stuff that we know about – health problems, mental health problems, lack of education, lack of access to support services, that kind of stuff."*

Accordingly, several CfE respondents and interviewees referred to the concept of the 'One Stop Shop', a model where advice, support and information provision is not restricted to a focus on energy or LCT *per se*, but is set up to respond to a wide range of needs and issues.[34] This was described as a form of wraparound support and encompassed support mechanisms relating to supplier/fuel switching, housing issues, welfare support, crisis provision (i.e., food parcels and fuel vouchers), debt management, among others. Making the process of accessing advice and support related to energy and LCT as simple as possible – and in one place with one organisation or case worker - is key. A number of interviewees outlined that providing this form of support would however at times involve referrals onto other specialist agencies, calling attention to the importance

of strong organisational networks across welfare, energy poverty, retrofit, health and wellbeing, and beyond.

Case Study One: Réseau Eco Habitat

Réseau Eco Habitat is a volunteer led project based in the town of Compiègne, which is located approximately an hour away from Paris in France. In the broader region, as one interviewee told us, "*the houses are 100 years old, but they were never well built to start with, and they're dotted around in small villages*."

Réseau Eco Habitat has developed a model whereby low-income residents living in energy poverty are provided with support to identify different government schemes that they might be eligible for, such as window replacements, insulation, and other housing upgrades related to the accessibility of the home if an occupant is elderly or disabled. As our interviewee continued,

> "*they figure out the whole package that an individual or a home is eligible for and, from that, they're often able to say, "We can, from the state, get funding for 70% to 80% of the cost of your total renovation, to make your house not just warm but make it liveable and to work for you." Once they're able to say that they have that level of funding in place, coming from the state, they can go with that person to the bank and get a loan for the 15% or 20% that person really needs, because the bank is no longer feeling like, "We have to fund this high-risk person at a very high level*."

Crucially, this support is provided by local volunteers, specifically a volunteer group from the Catholic Church. Each volunteer can work with individual households for up to two years, building a relationship, helping them to fill out paperwork, and generally providing mentorship and support with their retrofit; as our interviewee put it, they "*mentor them through the whole process […] they [are] an ally who is on their side and can explain, a little bit more, some of the stuff*." Our interviewee gave one specific example of a couple in their 60s – "*their house was really a disaster before the work was done […] then, all of the works got done and they just became people who are reengaged in the community. They don't feel ashamed of their house anymore*."

Born of a realisation that, as our interviewee put it, "*there's money out there, but the people who need it have no idea how to get it*", Réseau Eco Habitat encapsulates how holistic, community led advice and support can be so critical to supporting the most vulnerable households access the housing upgrades that they need, but cannot obtain on their own.

As well as the provision of wider advice and support (for example, in relation to debt or health), the evidence suggests that support which directly relates to new technology and heating systems is of considerable importance. CfE respondents and interviewees suggested that to have the greatest impact on energy poverty, the introduction of LCT into households must be accompanied by specific or direct advice and support. As noted, this could relate to choosing and accessing appropriate technologies, or being provided with guidance on how to use them (i.e., heating system controls). One interviewee explained that this was not just an issue associated with more modern, perhaps more complex, or less well-known technologies, but also with simple or more established systems and controls, such as typical boilers:

> *"These were people who'd accessed […] energy efficiency, energy advice, social support services […] We found […] that at least 68% of those householders needed a face-to-face or*

in-home intervention. A lot of those cases will be people not knowing how to use their boilers; the really, really simple thing of somebody coming in and showing you how to use your boiler, how to set it, and all that kind of stuff."

As well as supporting energy poor householders in being more confident and capable of controlling their heating systems, one interviewee discussed how a key opportunity also lies in the design and development of these technologies. It is not just about 'teaching' households how to use heating systems, but designing them in a way that makes sense: "*if heating controls are better designed, people will use their heating systems more optimally*".

It was also widely acknowledged by CfE respondents and interviewees that the most effective energy-related advice and support, whether focused on LCT or tackling energy poverty, or both, is that which is provided by trusted, often local sources: "*it's really about building trust and rapport, and building an understanding. To do that, you need those services delivered by trusted intermediaries, so local authorities and housing associations, Citizens Advice Bureaus, [and] community-based support organisations"* (see Case Study One above, for an example of this). However, one interviewee, representing a service that works with marginalised and vulnerable communities in Iceland, noted that, in addition to direct support from trusted intermediaries, other resources such as videos were also able to provide an effective means of communicating energy-related advice and support:

"They've made these, they're called energy crumbles, like short videos just teaching the basics, like how do you reduce your settings on your ovens, or how do you make sure regarding changing the air within the house without losing heat, how should you arrange your furniture, how should you try to build shelters around the house, you know, trees, and such, to reduce the cooling by air."

Lastly, some CfE respondents and interviewees highlighted that expert and impartial advice is crucial for helping households choose the optimal mixture of technologies to decarbonise their home heating most effectively, and in a way that has the most impact on energy costs and energy poverty. This was described as particularly important for rural areas, as commented on by one interviewee:

"I think that's the problem in terms of at scale for rural areas. You are never really going to get that [one-size-fits-all]. I think going back to the circumstances are all very different, whether you are doing a single farmhouse that is very, very isolated or whether you are doing a small village like my own, 300 people or more, one of these smaller towns, it is all going to be difficult."

Summarily, this evidence suggests that the installation of LCT may not, on its own, be successful in addressing rural energy poverty. If householders are not shown how to use their new LCT heating systems optimally, including how to link them advantageously to innovative tariffs such as Time of Use tariffs, the evidence suggests that their impact will be limited, and could even exacerbate (as opposed to alleviate) the depth and severity of energy poverty. Furthermore, the provision of advice and support alongside the installation of LCT can also highlight broader issues relating to debt, health, vulnerability, and/or digital skills, which the householder can subsequently receive further assistance with. Accordingly, the evidence points to the importance of delivering services such as the One Stop Shop and including within these services provision to support households with broader energy-related issues, as well as advice on LCT installation for their homes.

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Remedial measures

In addition, the evidence suggests that LCT should, where appropriate, be accompanied by remedial measures to improve the energy efficiency and 'liveability' of homes if it is to have the greatest impact on energy poverty. The most prominent and important remedial measure highlighted across the research was insulation, which was viewed by some as a critical first step to addressing rural energy poverty.

One interviewee, for example, stressed the need to improve the thermal efficiency of buildings *before* proceeding with any LCT installation in rural homes:

> *"[You] must do energy efficiency work on the building first. I think that, always, the aim, first, has to be to make the house as energy efficient as possible. You don't want to put a heat pump in and overextend the heat pump. The aim is, 'Let's reduce energy consumption first,' and then figure out what you need."*

However, the evidence does not just suggest that fabric insulation (e.g., external wall, loft) should be a singular focus, but that it could be accompanied by other forms of remedial action to improve the thermal efficiency of buildings, such as window replacements, draughtproofing, and other similar, smaller measures. One interviewee from Iceland, for instance, talked about "*how one of the initiatives that is being done by the state is to make people aware that they can preserve and reduce the energy cost by making smart choices with heating, glazing, insulation, heating pumps, and such*", which highlights the place of insulation and glazing among a suite of measures to reduce energy costs, in addition to heating systems and heat pumps.

Similarly, some evidence also suggests the importance of remedial works to reduce damp, mould, and rot as part of the holistic energy poverty offer. For example, between 2017 and 2019 the Scottish Government piloted an Energycarer approach to tackling rural energy poverty in two rural areas: Anandale and Eskdale (South West Scotland) and Moray East (North East Scotland). This approach aimed to provide support to vulnerable, energy poor households in rural areas who may require multiple points of contact and several face-to-face visits. An evaluation conducted by Edinburgh University concluded that numerous households required remedial works alongside heating system installations, but funding to complete these works was typically not available. The evaluation therefore suggested that a "*single finance mechanism which incorporates a range of physical measures (including heating, insulation and glazing) alongside remedial works (to tackle damp, condensation and mould) is required*" to have the largest impact on rural energy poverty.[35]

The evaluation of the Energycarer pilot points towards a final, important point regarding the combination of remedial measures, LCT, and advice/support in a holistic energy poverty offer. For some interviewees, addressing the thermal efficiency of buildings could only be effective if it were part of a broader approach to understanding and reducing the energy consumption of buildings. This approach can be described as neither fabric first nor 'folk first', but both simultaneously:

> "*So, for every single house, the first thing should be, 'How do we absolutely minimise the energy consumption?' That is not only through insulation, it's looking at the appliances and looking at people's habits. So, yes, and I think this is also true of projects that I know in developing countries, where they're taking small-scale electricity systems into rural villages for the first time. The first thing they do is go in and say, 'How much energy do you really need?' and they build a mini-grid that's going to meet that need*."

A second interviewee also discussed the importance of face-to-face advice when dealing with damp and mould issues:

> *"[It is] so important to get at other issues like mould and damp. It has to be addressed. If someone is going door to door to take a survey, one of the questions needs to be, "Do you understand what mould is? Do you understand what rising damp is? Do you know what it looks like? Do you know the impact it could have on your health?""*

In many ways, the sum total of this evidence points to the importance of developing holistic models and approaches to rural energy poverty, which could be described not as whole house, but as *whole home*. Some academics have noted that whole house approaches to retrofit sometimes treat the building, the physical property, as an entity separate from the practices, habits, and routines of households, as well as the broader economic and social position of its inhabitants (e.g. their work pattern, which shapes how much time they spend at home and when, or how many children they have, which shapes energy use in other ways).[36] This was also noted by some interviewees, who criticised, for example, the ways that Energy Performance Certificates are used in the UK to model home energy performance because they do not take into consideration the multifarious ways that energy is actually used by people inside their home. As one interviewee told us, the same property can have vastly different running costs, depending on how it is inhabited and by whom.

The holistic energy poverty offer would therefore be one where the home is looked at as an integrated whole, encompassing the physical property and the specific way it is inhabited, and this constitutes the starting point for a consideration of what combination of advice/support, LCT, and remedial measures might have the greatest impact on energy poverty, while simultaneously decarbonising home energy consumption. This was best summarised by one CfE respondent:

> "*A holistic approach needs to be taken. This should include building fabric improvements and also adequate engagement with residents etc. Simply installing a renewable technology without addressing these other areas either won't work at all, or will be much less effective. The distinction between targeting reduced energy costs and reduced carbon also need to be understood clearly e.g., simply installing heat pumps may well reduce carbon, but it may not deliver any energy savings for residents and could have the opposite effect, especially if the building fabric is not considered properly along with occupants understanding of how to use these systems."*

3.3. Community energy models

Having considered different combinations of LCT and holistic energy poverty support in previous subsections, the discussion now moves to certain approaches and notable business models within which they can be achieved. The first and most prominent business model to emerge from the research was community energy, and for this reason they receive sustained discussion in this subsection. Although there is no widely accepted definition of what constitutes community energy, following Martiskainen, Heiskanen, and Speciale, it is defined for our purposes as citizen-led activity which aims to develop sustainable energy projects for the shared benefit of communities.[37]

Drawing on available evidence, and responses to the call for evidence and interview data, this research proposes a typology of community energy projects which is set out below. Following this, the ways in which community energy projects can or do address energy poverty in rural areas are considered.

Typologies of community energy projects

The research has identified three main types of community energy project: a) circular, b) domestic community led, and c) non-domestic community led. In practice there are not distinct boundaries between these groups, but they each have unique characteristics that are useful to draw out, including their geographical variance across the NPA.

The first type of community energy project is defined by its use of local material resources and its commitment to circularity. Circularity is understood here primarily in terms of circular economy approaches, which are broadly premised on the reuse and recycling of resources across different areas of national or global economies.[38] Practically, community energy projects of this type tend to use waste or excess materials from other economic activities, such as farm waste, biomass, and wood chippings, but also make use of geological or natural sources of renewable energy, such as geothermal. These materials are used to produce heat and power, either on or near the site of their production, or after transportation to a more central processing plant. The heat and power generated through these processes is subsequently supplied to local homes and businesses, sometimes through district heating networks, or is sold to intermediary suppliers or industrial users. One important feature of this type of community energy project is that the scale of generation and production is typically not at the household level; it is usually defined by larger centres of generation such as biomass plants, as opposed to household levels of generation such as rooftop solar panels or heat pumps. However, there is limited evidence that this type of project has been linked to energy poverty, a point which is considered further below.

The evidence suggests this type of community energy is most associated with the northernmost NPA countries (especially Iceland and Nordic countries), and with other EU states such as Germany. For example, one successful example of this is the bioenergy village concept. Bioenergy villages can be defined as "*community-led bottom-up initiatives that organise and finance the implementation of their own local heat supply grid that supplies households with heat produced from biomass*."[39] They are based on a local heat production unit which is typically owned by local farmers, and the supply grid is owned and operated by local communities to supply households and businesses in the area with heat. One study suggests that bioenergy village projects in Germany and Austria have achieved carbon savings of between 56% and 97%,[40] and they were aptly described, although not in terms of bioenergy or circularity, by one interviewee thusly:

> "*[Q]uite common are also these cooperative initiatives so that you have a community and they create a cooperative. [In this example] they run heating plants, so they have all the supply because they are landowners themselves, forest owners. They have the raw material and they provide that material to a heating plant which they are running themselves. They have the whole value chain, from the forest to the sold energy in their own hands and they create money with that. For example, in that village and that cooperative I'm referring to, they replaced oil. With that, the money stays in the region, in the village, and doesn't leave the region. The value stays in the region. You create jobs in the region, and you save oil and you save money, and you save CO2 emissions*."

The second typology is defined as domestic community led. Community energy projects of this type typically involve the installation of solar PV, heat pumps, and/or microgeneration technologies on/in households in specific communities. This has similarities to the third typology, which is defined as non-domestic community led. Projects of this type involve the same or similar technologies as the second type, but they are not installed at household level. Instead, they are installed on non-domestic buildings such as schools, community centres, hospitals, and other larger types of building.

These two types of project garner funding from an eclectic range of sources, including community share offerings, regional or national community energy funds, charitable grants, inward investment from other community projects, and private investors. Importantly, interviewees highlighted that both of these typologies are sometimes not concerned primarily with energy, but are instead defined by the specific issues local actors wish to address in their own communities. For instance, some community energy projects may begin life as a community food sharing scheme before snowballing into energy, while others are stimulated by local authorities or other actors approaching community groups to pitch a particular project. As one interviewee, a UK based academic, told us:

> "*So, what we tended to find is where there was a strong sense of community and they wanted to do things together, they would do various different projects together. Sometimes, community energy would be that project. Sometimes, it would be community allotments and a, kind of, sharing scheme with an allotment. It could be around a shared transport system because they didn't have public transport, so they looked to develop some kind of shared transport system* […] *I think it's not just looking at community energy, is it? It's looking at the community in general and understanding what the issues are within that community and the role that energy can play in improving that community. So, I think it's wrong to just look at the energy in isolation. I think you need to look at the, kind of, employment that's there and the transport issues and work out how, as a whole, you can actually deal with those issues*."[41]

There is some evidence that community energy projects of all three types do not engage with energy poverty concerns, or do so only tangentially.[42] Some CfE respondents and interviewees described community energy projects as often exclusionary to low-income households, and/or being led by more affluent members of the community who have the time, social capital, and expertise to make them work effectively. For example, one interviewee with experience of working with and researching community energy groups in the UK told us that:

> *"What we did find in the rural communities was there was a lot of interest in the group buying schemes for fuel, but also group buying schemes for things like air source heat pumps or PV panels […] but when you start talking about buying air source heat pumps or PV panels, that tends to only really benefit the wealthier people within those communities. You know, the poor people just physically don't have the capital to pay for those sorts of things."*

Interestingly, this interviewee had also worked with community groups who had actively tried to engage socio-demographic groups more likely to be living in energy poverty in the UK, such as young people and ethnic minorities/diasporas in particular places. The interviewee narrated how community groups had attempted to organise targeted information sessions in community centres and other shared public locations:

> *"They tried to do various, sort of, outreach events where they would have community events to come and talk about it and try and encourage more people to come, but they tend to find the younger people thought they were too busy to come, and the ethnic minorities just weren't that interested. So, it's something that is a real struggle within those kind of community energy groups."*

Despite this, the research did identify some evidence that community energy can and does play a role in alleviating energy poverty.[43] This evidence is summarised in terms of current and future opportunities in Table 3.1. below.

Current or future opportunities	Rationale	Energy poverty link
Reinvestment of community profits into energy efficiency schemes	Profits from community energy projects can be reinvested in community retrofit projects, targeted at low-income homes[44]	Improved energy efficiency after retrofit leads to lower bills and increased home comfort and warmth
Peer-to-peer electricity trading	Peer-to-peer models allow consumers to trade locally generated electricity with each other, as well as with the grid[45]	Excess power can be 'donated' to households in energy poverty,[46] or used to offset energy bills
Inclusive and subsided ownership structures	Encouraging energy poor households to own shares in community energy cooperatives by providing them for free[47]	Enables typically excluded energy poor households to engage in community energy, resulting in small financial gains and improved energy market engagement
Expert governance and involvement	Encouraging local energy poverty experts to sit on community energy boards or steering groups	Improved consideration of the needs of energy poor households and maximisation of potential benefits through other opportunities
Reinvestment of community profits into advice and support services	Profits from community energy projects can be used to employ energy poverty advice and support officers[48]	Officers can provide advice and support with energy efficiency, supplier switching, income maximisation, and other areas that reduce energy poverty
Community flexibility clubs	Community energy projects provide flexibility to the grid at aggregate or community level, with benefits shared among community, similar to current oil buying clubs in rural areas[49]	Lower energy bills without the detriment of rationing usage, or reinvestment of savings
Local or municipal authority engagement	Local/municipal authorities employ community energy groups as trusted intermediaries to engage 'hard to reach' households[50]	Greater likelihood of energy poor households being identified and receiving the support they need
Behaviour change	Community energy projects educate members of community about energy efficiency or energy saving tips[51]	Reduced energy bills through consumption reduction, empowerment
Community project snowballing	Community groups develop projects in other areas (e.g., food sharing, community gardening)[52]	Cheaper provision of other essential needs (e.g., food, employment opportunities) to energy poor areas

Possibility of enhanced Return on Investment (RoI)	Higher RoI increases the possibility of financial community benefits[53]	More profit to reinvest into energy poor services (e.g., community retrofit, advice and support)

Table 3.1 Links between community energy and tackling energy poverty

Drawing on the specific examples above, these opportunities can be grouped thematically into four broad areas of focus or action, including: energy market engagement; organisational structure; (re)investment; and actor engagement.

Energy market engagement: Interviewees provided examples of how community energy groups can lead to higher levels of energy market engagement among rural households, which can have corresponding impacts on energy poverty. One interviewee, for example, discussed the importance of Oil Buying Clubs for reducing oil costs in rural areas of Northern Ireland. They are premised on the fact that oil is typically cheaper if bought in bulk, but low-income households cannot afford to do so. Oil Buying Clubs therefore bring communities together to bulk buy oil as a group, leading to cheaper oil for each individual household than if it had been purchased separately. This model could be replicated for both the buying and selling of renewable electricity, perhaps through an 'aggregator', a body that mediates between local community groups and electricity networks to trade electricity. Another example concerns peer-to-peer energy trading, where electricity is traded locally between consumers, rather than exclusively with the electricity grid. Some evidence suggests peer-to-peer models could enable the donation of locally generated excess electricity to rural energy poor households, reducing energy bills and thus alleviating energy poverty.[54] Across these examples, what is common is that collective community organising can lead to a greater engagement with the increasingly digitalised and low-carbon energy markets than energy poor households can achieve individually, leading to benefits that are greater and more evenly spread throughout communities.

Organisational structure: Evidence suggests that community energy groups can best address energy poverty in rural areas when the needs of energy poor households are built into organisational structure from the beginning. There were two primary examples of how this could happen: firstly, one community energy group in England has on its board of directors an academic energy poverty expert, who was able to embed energy poverty concerns into the organisation from the beginning. Replicating this practice could ensure energy poverty is considered at every stage of community energy decision making, from the (re)investment of profits to the uses of surplus electricity generation. Secondly, one example uncovered in the evidence review detailed a plan to provide free shares in community energy cooperatives to local low-income and vulnerable households.[55] The intention is that this can ensure energy poor households receive a share of any yield accrued over the lifetime of the project, and encourage the genuine inclusion of low-income households in the activities and decision making processes of community energy groups.

(Re)investment: There is ample evidence that grant income and/or profits generated from community energy projects can be and are (re)invested in schemes that aim to address rural energy poverty. For example, the research identified a community energy group called The Cheese Project, a Community Interest Company in Bristol, England. The Cheese Project aims to enable households to identify and reduce domestic heat loss, and it does so by performing surveys of homes using thermal imaging cameras. Through grant funding obtained from various local sources, The Cheese Project offers these surveys free to vulnerable and low-income households across South West England, with the aim of subsequently providing advice to householders on how their homes can be made more thermally efficient. A second example, also from England, concerns a community energy group who invested income from renewable projects into setting up an energy advice service for residents of

the South West of England. By linking the generation of renewable energy and schemes which aim to alleviate energy poverty, these examples show how community energy can be a bridge between deploying LCT in rural areas and alleviating rural energy poverty.

Actor engagement: Finally, evidence suggests that community energy groups could provide a link between other actors concerned with reducing energy poverty, such as local/municipal authorities or social housing operators, and the most vulnerable energy poor households in rural communities. One interviewee, for example, agreed that local/municipal authorities have a role in addressing energy poverty, but commented that:

> *"[…] in an ideal world, yes, they should be doing a lot more, but in reality, I think the relationship that they have with people is perhaps not the best one to have. They might do better to go through intermediaries who have that kind of connection with the communities and are better able to talk to them. So, one of the organisations that we work with was a group in [a local town] who work particularly with local communities and they, kind of, do outreach with those local communities. They have people who work actually in the communities that are embedded in them. So, they were very well-trusted. So, when it came to anything around community energy projects or anything around improving the environment, the council actually went to them to be their intermediary and the people to talk to within that community."*

Summarily, if community energy groups take on the role of an intermediary between other actors and residents (including energy poor residents) in local communities, the possibility that the deployment of LCT and addressing rural energy poverty can be linked together increases.

3.4. Other approaches and models

The previous subsections have set out three key thematic areas for opportunities that were identified across the research, exploring the mix of technologies available, the role of holistic provision, and community energy models. This fourth and final section draws focus to a number of additional findings related to opportunistic approaches and models in the context of linking LCT to efforts to tackle energy poverty in rural areas.

One example of the potential positive impacts of better aligning the implementation of LCT with tackling energy poverty in rural areas relates to the wide-ranging social benefits that may be realised. Several CfE respondents and interviewees called for greater consideration and discussion of social and economic impact in the context of this work, drawing attention to aspects such as health and wellbeing, isolation, and the local economy. As one interviewee, a Scottish-based academic, explained:

> *"Yes, we need politicians to understand what this is and figure out how to build policy around it, but the point, to me, that's really missing, is looking at the social impact, particularly. So, the social impact projects that are demonstrating they're feasible - not as a charity/public service kind of activity, but as a small business they're feasible. If those solutions can be scaled up, then that can be the policy bedrock, in a way. Policymakers, typically, are not aware of those projects."*

One interviewee explained that at present, a barrier to achieving this is a gap in expertise related to assessing and communicating the costs involved and benefits available. This was closely linked to and highlighted the importance of frameworks around social return on investment and cost-benefit analyses, for example, where decisions around significant investments in LCT, such as those made at a community level, can be made with greater confidence in terms of risk avoidance. This was

described by one interviewee as a clear opportunity for bringing in key expertise to further strengthen existing programmes of work:

> *"We do these calculations and things like that and then we give some hints what technology is suitable for that scale, because of course there might be a nice machine which produces lots of cubics of chips per hour, but it might not be worth it for the entrepreneur to run these kinds of machines because it's too expensive or something like that. These calculations […] are very important, especially for rural entrepreneurs and SMEs because they cannot afford always the most powerful technology and the best technology. They need to look at the investment side as well."*

Other opportunities to include a wider pool of expertise were noted. For example, one interviewee, representing a media outlet working across Europe, explained the value in having clear communication that can effectively target and adapt messaging for different audiences. In a policy landscape obscured by complexity, such a role is likely to be highly valuable:

> *"[…] our role [is] trying to reach two audiences, really, the people who are in energy poverty, "How can we help them develop new energy habits or find where they can get help?" The second audience, which I think is more important to us is, "How do we connect the people who are working in different sectors of this?""*

Across the research, there were numerous mentions of one particular voice that is often excluded from the development and design of such policies and schemes: the householders and communities themselves. Several CfE respondents and interviewees noted the importance of involving communities in meaningful ways, and the opportunities for projects and policy to embed co-production approaches into the design and delivery of programmes. In Iceland, work with rural and remote communities – termed 'Fragile Communities' – has been particularly effective in this regard, using workshops and deliberative processes to understand community priorities, whether linked to energy, housing quality, health, or transport, among other key areas. As noted in the previous subsection on community energy, allowing communities to define their own problems and priorities can lead to projects which snowball either into energy from other areas, or from other areas into energy. As one interviewee told us:

> *"[…] we start by developing these goals with inhabitants. It can be something regarding just the community, you know, bettering the lives of the inhabitants. It can be connected to infrastructure, better roads, better conditions in the schools, or starting a local shop/supermarket. So, it connects to everything."*

As demonstrated in the Fragile Communities project in Iceland, widening the scope, where possible, beyond a focus on LCT and energy has positive impacts on the quality and level of support for, and engagement with, rural and remote communities. It also provides a model for delivering projects that has the potential to draw on local resources and expertise that, on occasions, may minimise the cost of delivery (see Case Study Two for an example). A project in Portugal provides a useful illustration, where, with a focus on home retrofit and other minor maintenance work, volunteers were recruited to work alongside local, skilled tradespeople:

> *"[…] there's also a project in Portugal […] it's another home renovation scheme. What they do is they have a small group of skilled and licensed tradespeople who will take the group of volunteers and go out to a rural home and fix the home over a week. So, it's a volunteer opportunity for young people to do something for the community, as well. It's not like young*

people just go and, with no knowledge, try to fix somebody's house, there are definitely the right tradespeople there to help them."

As well as volunteer schemes, there are also opportunities to make stronger connections between community groups or community-based organisations and industry, where, as one interviewee explained, there are often opportunities to access LCT for free. The opportunity here, then, is to assist such companies in making links with appropriate organisations or groups on the ground:

> *"[…] you have got all these vast, remote communities and all these vast community groups […] there are literally hundreds of companies and organisations who are giving this stuff away […] We are actively trying to find the community groups, but the community groups don't know that we are there […] So, the thing that occurs to me about all of that is about this, if there were just some magic wand that you could wave, to suddenly say to 500 community groups, "Look, here is what is available. Here is how it works, and this is what the benefit would be for the fuel poor, who you would need to, yourself, identify and target within your region." If you had that collective together in a room for a day, think of the magical work that you could do. You could identify the right community groups in the right scenarios and the right funding for the right projects. Within a year, you could have achieved so much."*

Relatedly, one interviewee noted that a small but positive impact of COVID-19 was that it had forced some existing community groups to operate almost if not entirely online, and this had resulted in more connections between community groups and appropriate sources of support: "*Connectivity has improved in that regard. Their community groups are beginning to understand themselves, because of the pandemic, they are beginning to understand the power of technology.*"

Case Study Two: Insulation from nothing

One of the issues highlighted in this section is developing models that draw on local resources and minimise the cost of delivery. A particularly innovative example of how this can be achieved was provided by one interviewee.

In Hungary, a university professor has developed a process for creating insulation fabric from crop waste and recycled glass. Specifically, the process creates a type of brick which can then be installed on the inside or outside of a home. Faced with the problem of utilising this process to treat rural homes in areas hundreds of kilometres apart, the university professor installed all the necessary equipment for recycling the waste and manufacturing the bricks in the back of a van. He will then drive the van out to a rural property and use their own crop waste, combined with the recycled glass he carries in the van, to make and install the insulation on site. As the interviewee told us, "*it's amazing and he's just at the point where he's proven that the materials work [and] the process works, and what he needs now is the funding to build a couple of these factory vans and get out and do a few houses. When I hear a story like that, I just think "somebody needs to give that guy €1m and let him go.*""

This example demonstrates how innovative, bottom-up solutions can be developed to treat rural properties, and that they can sometimes come from the unlikeliest of sources. However, as hinted at in the aforementioned quotation, the most difficult next step for innovative solutions such as this one can be making the transition from proof of concept to business model to receiving funding, and final evaluation of the impacts.

In summary, this subsection has discussed several different approaches and models for the implementation of LCT in rural areas. It is clear that there are numerous opportunities relating to linking together industry, SMEs, community groups, and other actors to develop innovative models to tackle rural energy poverty. However, it has also touched upon some of the barriers to transforming opportunities, innovations, and prospective models into reality, and it is to this that the next section now turns.

4. Barriers to low-carbon technology in rural areas

A key area of focus within this research has been to identify and better understand not only the opportunities, but also the current barriers to delivering LCT in a way that alleviates or eradicates energy poverty in rural areas. This section focuses on the key challenges identified in the evidence review, and some of the barriers raised by our CfE respondents and expert interviewees. This section is structured thematically around several key barriers that encompass issues associated with a) funding and policy certainty, b) complexity, and c) public awareness and trust.

4.1. Funding

Long-term funding and policy certainty

The most significant barrier to introducing LCT in rural and remote contexts identified in the research was a lack of long-term policy and long-term funding commitments from national and supranational governments. Considering the former, the evidence review identified several key studies where recognition of the importance of developing coherent, extensive, and long-term strategies for decarbonisation and tackling energy poverty was drawn out and argued for. For example, analysis from Community Energy Plus suggested that countries with the most impactful LCT adoption in rural areas, such as Austria, Denmark, Sweden, and Germany, have coherent and extensive heat planning policies in place that provide long-term confidence, cross-party political consensus, and clear direction for stakeholders.[56] Additionally, in their analysis of how to reduce carbon and poverty in Scotland's rural areas, Common Weal's Energy Working Group recommended that the Scottish government "*must take responsibility for a coordinated strategy to enable the transition.*"[57] This included long-term steps to model electricity grid capacity in rural areas, ban new oil and coal boilers, and ensure that stable and reliable funding is available for heating transitions, possibly through the Scottish National Investment Bank.

In terms of supporting low-income and otherwise vulnerable households and communities in this context, research from the Centre for Sustainable Energy in the UK has argued that when working with such demographic groups there is even greater importance on larger-scale and longer-term projects. This is not only because 'stop-start' funding for short-term projects instils mistrust among communities, but also because longer-term funding streams "*provide greater opportunity for time to be put into building confidence and faith in local residents, so that they feel empowered to get involved in a project*." This research also emphasises the need for long-term policy frameworks which are "*cross-departmental and less vulnerable to changing political landscapes*."[58] This evidence indicates that developing LCT in rural areas requires significant commitment in terms of long-term policies, funding mechanisms, and support.

Respondents to the CfE and the expert interviewees further supported these key conclusions, highlighting the extent of resource required to establish such policies and projects, and lambasting the waste that occurs – in terms of networks, systems, and impact – when these are only short-term in nature. One interviewee working in Iceland noted the benefits and added reliability in this regard where such policy mechanisms and funding streams were state-funded and controlled. However, as this interviewee highlighted, even this does not provide an overall guarantee that such schemes and initiatives are not susceptible to funding cuts, requiring programme delivery teams and managers to closely monitor funding cycles and streams. As they explained:

> *"We want to place long-term structure around initiatives, because, otherwise, it's a lot of effort to get them introduced for some blitz effect, but then you still have, maybe, a part of*

the communities that really need this in the future. So, the benefit of having it within the state is, once you have the programme going, it is more difficult for them to put it down. But then we always have to make sure that the state doesn't forget funding the project, because there's always this small clause in every programme, 'based on state funding', so you have to be very vigilant, and exploring and knowing what the state has put into these programmes."

As this quote makes clear, short-term and frequently changing policies make it more difficult for delivery teams to plan programmes with certainty, something that is potentially required to an even greater degree when working with low-income, vulnerable communities.[59]

Funding at the household level and upfront costs of LCT

As well as discussion relating to larger-scale funding streams and policies, almost all the respondents to the CfE and many of the interviewees considered the implication of funding at the household level. Respondents told us that **installation costs and access to funding represented a significant issue** in the context of their work, whether in terms of delivering LCT or tackling energy poverty in rural and remote settings, or both.

Across this evidence, the high capital cost of LCT, especially in rural areas or in hard-to-treat properties, was cited as one reason why low-income, vulnerable, or energy poor households were excluded from accessing it. **A centralised, free at the point of service model of funding was pitched as the ideal**. A lack of coherent long-term strategy or direction was cited as the reason for this, and existing funding models were described as unfair and inequitable with rural and remote communities particularly disadvantaged:

"Upgrades should be funded by a central mechanism under a free at point of service principle. Then recovery of costs may be done over a mortgage length e.g., 25 years at central bank interest rates and linked to [taxation] so that the fuel poor who are supported by benefits are covered as normal but those who can pay will do so. This will allow equity, agency and ability for universal uptake to encourage the SME or municipality to set in place supply chains and labour for the long-term delivery programme and gain credible investment."

This notion was supported by other evidence, such as a report detailing customer experiences of installing LCT in Northern Ireland, which concluded that "*the initial financial outlay is likely to [constitute] the main barrier for people switching to renewables. Therefore, if uptake of renewables is to be encouraged, grants and incentives will be important*."[60] In other words, policies and programmes that provide financial support to energy poor households, ideally 100% of the full costs of installing LCT and any related measures (e.g. insulation), were viewed as a fairer, more equitable way of ensuring that they can access the undoubted benefits of new technologies and retrofits. As noted in Section 3.1., in discussions of heat pumps and solar, the evidence suggests that unless these upfront costs are covered, take up among energy poor households in rural areas may be severely constrained.

Capital cost was not positioned as a barrier only for households. Costs were also regarded as prohibitive for landlords with properties in the private rental sector, an area of key focus in tackling energy poverty (particularly in the UK context). One interviewee, based in Northern Ireland, highlighted a need to challenge the misperception that private landlords have both large portfolios of properties and the required capital to invest in these properties.

> *"Private landlords are one of the biggest problems because typically in Northern Ireland private landlords [have] only got two houses. It's not to say they're like a housing association. So, they're a real difficulty because they don't have the funding."*

A further issue associated with costs and funding relates to the high capital costs for infrastructure provision, especially when doing single house installations, as is common in rural settings. The heterogeneity of properties and those living in rural settings compared to urban settings was noted as a contributing factor to higher installation costs. Considering potential mechanisms to overcome this barrier, one CfE respondent stated that a focus on networked heat pumps and more communal solutions could bring costs down, but that it is still prohibitive. As discussed in Section 3.1., another noted how key examples of LCT, such as heat pumps, may be unsuitable for many rural properties due to such cost implications.

Related to the need for larger longer-term national-level funding, many respondents and interviewees noted how the implications of the stop-start nature of funding mentioned above had direct implications for the shape of their work on the ground supporting households and communities. For some, this resulted in them overlooking LCT altogether. As one CfE respondent noted:

> *"We concentrate on energy saving measures as there is no funding available to help low-income owner occupiers install renewable/low carbon technologies."*

As with policy-driven definitions of energy poverty (discussed in Section 2), funding models and schemes were regarded as ill-fitted for everyday interactions with householders. For those with some access to personal funding for measures, making the case for capital expenditure on LCT against the saving to be made in operating costs was regarded as extremely difficult. This was particularly the case when comparing higher initial costs with higher savings in the long term, versus lower initial costs with lower savings in the long term. In other words, the figure assigned to the initial capital expenditure cost plays a more significant role in the householder's decision-making compared to figures associated with ongoing energy costs and savings. For energy poor households, with little or no access to capital of their own, this barrier is particularly acute.

Funding for LCT and energy poverty alleviation schemes were also considered to be geographically uneven – "*like a postcode lottery*" – often based on local, regional, or municipal administrative boundaries, leading to a seemingly disparate distribution of funds across areas despite similar needs. As one CfE respondent noted,

> *"[…] one district we work in has a grant scheme to help low-income households get first time central heating. However, another district has no such thing, and it can be hard to find alternatives*."

A final point worth noting in relation to funding concerns cashflow, and the challenges faced by middle actors, those who typically deliver a service that is equidistant between national or government level funding bodies and providing direct household support. For example, as the quote below illustrates, time lags between the completion of work (i.e. the installation of LCT) and payment from grants can be so significant that contractors deprioritise work, in this case, on properties where the household is experiencing energy poverty:

> *"One of the problems that [this project] runs into is a cashflow thing. So, he has this network of contractors who are willing to do the work on his behalf, but before he can get the funding from the government, he has to demonstrate that the works have been done and provide the*

receipt. So, there's this lag period before he can pay out the contractors. He says if the contractors get offered another job that's going to be finished and paid quickly, they'll push his jobs back onto the back-burner. Yes, we're trying to figure out a cashflow solution to that."

This example, and others noted in this section, demonstrate that barriers and challenges with funding are not solely the concern of low-income households who do not have sufficient capital to invest in LCT. Frontline services, landlords, and contractors also face barriers in the context of LCT and tackling energy poverty. As noted elsewhere, to effectively and efficiently deliver on schemes and policies focused in this area, it is vital that the process is accessible – in terms of ease of understanding, even distribution across regions, mindful of heterogeneity, and underscoring all of this, that it is sufficiently and reliably funded in the longer term.

4.2. Policy complexity

Whether assessing the policy landscape, working for a frontline organisation, or seeking support as an individual household, the research illustrated that alongside funding, policy complexity is viewed as a significant barrier to the rollout of LCT. Similarly, policy complexity is also widely accepted as a contributory factor impeding efforts to tackle energy poverty, including energy poverty in rural and remote communities.

There were several ways in which complexity was discussed across the research strands. The language used in communicating related policies and schemes was a common issue, for example: "*You needed an advanced degree in government language or whatever to be able to even do it."* The accessibility of schemes, particularly in more recent years where information has shifted to online by default, was also raised as a significant barrier in this regard:

"But if you're visually impaired, you'll struggle to deal with online information. If you're hearing impaired, you'll struggle to deal with somebody over the phone. If English isn't your first language, you will struggle with both. There are all these barriers amongst the most vulnerable for dealing with phone calls and dealing with online information."

For some, there had been a clear failure in policy development and design to date, where opportunities for co-production and meaningful consultation with the people such policies and schemes are designed to support have been routinely missed. As one interviewee, a UK based academic, explained:

"It's a bit like computer programmers, isn't it? You know, they don't tend to be the users. They don't actually understand what people want at the end of it. So, they produce something and go, "This is fantastic," and the user's going, "Yes, but that's not what I wanted it to do," and these schemes inevitably seem to end up a bit like that, and you end up with a whole new business model where people come in that you pay to do it for you because they specialised in it and learnt how to do it. Well, yes, I think it's one of those things where you just put your head in your hands and go, "Oh, they've done it again, haven't they?""

Another interviewee noted similar issues when reflecting on their experience of working on evaluations of large-scale policy rollouts, specifically focusing on the implications of policy complexity in terms of householder and community engagement with such schemes:

"So, there were all those kind of issues around, "Yes, you're consulting us, but we don't really feel consulted. You're telling us you're doing this, but it feels like it's been done to us, rather than us really being involved in it.""

Complexity as a barrier is not only related to the use of unusual or unhelpful language and issues of procedural complexity; it also links to reliability and certainty. A number of interviewees discussed the policy landscape as a complex system that is ever-shifting and extremely difficult to navigate. Examples of shifts related to scheme delivery, eligibility, measures and packages, processes for accessing grants or works, and so on, and these were cited as elements that could and did change at unexpected moments during the lifetime of a policy. As one interviewee explained,

> *"I think if you talk to anybody about central government schemes for energy, they'll just say, "They're so complex. I don't know how to access it, and then it changes. So, I think I'm going to be able to do X, Y and Z and then it changes, and the goalposts change left, right and centre." So, I think on the whole, central government schemes have not been that helpful."*

The above has detailed examples of how complexity operates as a barrier at the household level, influencing how easy or difficult it is to access a scheme or grant, and how this is closely linked to the level of meaningful engagement households and the services that support them can have. Beyond the household, complexity was also described as contributing to a situation where policy aims and outcomes, while operating in the same area, were conflicted. One example of this, shared by academics working on the acceptance and implementation of LCT in Wales, related to decarbonisation policies in the UK. As they noted:

> *" […] there is the issue of different decarbonisation policies coming into conflict with each other, and that being things, for example, like quality on the one hand and low carbon heating on the other, particularly if you are going biomass. There are aspects of the transition thinking that isn't fully integrated with each other."*

What these findings highlight are the implications and negative consequences – whether relating to competing aims, disengagement, or inability to effectively support – in having a policy landscape that is shrouded in complexity. In delivering LCT, and doing so in a way that maximises efforts to tackle energy poverty effectively in rural and remote contexts, there is a need for clarity in policy aims and offerings. Cross-sectoral, collaborative approaches that draw on the views and experiences of those that such policies are designed to support are, as the evidence suggests, likely to have greater success. Finally, simplicity will mean different things to different audiences and this likely indicates a need to have multiple ways of communicating policy where the language used, method of communication, and style also differ accordingly.

Before proceeding to the next subsection, it should be noted again that barriers relating to funding and complexity are not uniform across all NPA and EU countries. Research by Community Energy Plus, for example, underscored that:

> "*Countries showing the highest deployment of low carbon heat are also characterised by long-term government support and policy stability. In Austria, government grants have been in place for over 25 years, with many of the key delivery agents remaining the same, providing consistency and familiarity. The same situation exists in Denmark, Sweden and Estonia where extensive heat planning is in place, delivered locally and supported nationally. Coherent policy frameworks have fostered long term confidence and investment, with consensus across political parties as to how to achieve long term energy security*."[61]

However, as discussed in this and the previous subsection, the evidence is mixed on the extent to which these policies are fully inclusive of, and accessible for, energy poor rural communities, a point which will be returned to in Section 5.

4.3. Public awareness and trust

A final barrier to the implementation and take-up of LCT is limited public awareness of LCT as a heating solution in some NPA and EU countries. It has been frequently demonstrated that although public awareness of climate crisis and the need to reduce carbon emissions is high, this is typically not strongly linked to domestic heating and is not driving any widespread uptake of LCT, especially in the UK context.[62] Studies have also shown that higher levels of knowledge and awareness of LCT is strongly correlated with higher levels of educational attainment, and especially the presence of university degrees in STEM subjects.[63]

While acknowledging the role of educational attainment in awareness of such schemes, it is important to note that the evidence review found that a lack of awareness is often linked to a lack of confidence. In a review of rural energy poverty by Community Energy Plus,[64] for example, this lack of confidence was tied to the reliability and user-friendliness of LCT in the home, and how, if lacking, this creates a scepticism towards the viability of LCT as a rural heating solution. The same research also noted how a lack of awareness can be influenced by cultural norms that normalise individually owned and controlled heating systems (e.g., gas boilers or heat pumps), rather than community or collective heating systems such as district heating, solar PV, or biomass. Summarily, this suggests that for LCT to be successful in addressing rural energy poverty there needs to be enhanced communication, education, and community engagement to increase awareness and tackle negative perceptions where they exist.

One opportunity to raise awareness of available schemes and grants is through the provision of holistic advice and support encompassing energy needs and services, as discussed at length in Section 3.2. However, providing this holistic support is not without challenges, and a key barrier identified by interviewees was the ability to reach those that may be difficult to reach but often most in need, sometimes referred to in the literature as 'hard-to-reach' groups and communities.[65] Those living in rural and remote contexts often fall within this definition due to added difficulties in terms of geographical reach and other related issues, such as the heterogeneity of properties, and such communities are also defined as having fewer opportunities to connect with local services and groups, where awareness raising may be implemented.

In overcoming this barrier, interviewees shared key learnings from past experiences where success in awareness raising of LCT among rural and remote communities had been found. Notably, this involved one key element in the approach taken, that LCT project officers must engage with communities in settings that are already used and occupied in day-to-day life (e.g. community centres, village halls, and cafes[66]). This could even be virtual settings, such as online housing forums. As one interviewee in Northern Ireland noted, one example can be found in an oil buying club which brings together sizeable groups of people, maximising the reach of messaging around efforts to tackle energy poverty and the installation of LCT:

> *"[that] has got connections to 400 different tenant groups across Northern Ireland, across housing schemes. There's probably reach across local communities, and because of that, we see ourselves to be the best people to try and influence these kind of groups. So, if you're trying to get a message out […]"*

However, as one other interviewee noted, in reaching the hardest-to-reach, including those that may be not have reliable internet access or the skills and competencies to use digital technologies effectively, a presence in the community is vital for awareness raising:

"[…] not everybody has got access to broadband and not everybody has got a laptop like you and I have, sitting in front of us. When we get out of this pandemic and we can go back to seminars and public meetings, yes, the simple fact is that you can target 150 people very quickly in one evening, in a community hall, by one well-spoken expert who is going to stand up and speak in their language. Not in a language that they don't understand. Even if he has to have a PV panel in his hand to say, "Does anybody know what this is and how it can benefit you and how that might work? Do you all understand what insulation is? Do you all understand how to keep your costs down with regards to your electricity bill and with regards to your heating? Here are a few handy tips.""

Underscoring much of the evidence that has examined public awareness, how best to establish meaningful engagement, and ultimately how to improve uptake of schemes, including the installation of LCT, is the role of trust. Across the CfE responses and interviews, the message was clear: to work more effectively with households and communities, and improve take-up of LCT while tackling energy poverty and other vulnerabilities, trusted sources should be identified, utilised and valued. In terms of barriers to the take-up of LCT, related advice, support and information provision should not come from sources where trust was low:

"If it is coming from energy providers, they are not necessarily going to trust that that's in their best interest because the sense is that the energy providers are going to want to be maximising profit."

The role of informal sources was acknowledged as trusted sources of support, and the power of word-of-mouth had both positive and negative consequences. Get it right, and the positive experience of a scheme or service would be shared; get it wrong, and the ramifications, particularly in area-based approaches and those located in close-knit communities (such as those in island or remote settings), are significant.

5. Learning from others: policies and insights for learning for successful energy poverty alleviation through low-carbon technology

> "*Basically, from a policy point of view, there are many factors that make the operational environment – we always talk about operational environment – different in these regions and in departments. It's not as simple as just take the example and do the same thing elsewhere. It doesn't work like that. We have noticed that many times now over the past years. There are good examples and there are not so good examples and there are reasons why certain cases failed and some other cases were more successful. It is very case specific, let's say it like that."*[67]

This final section considers how successful various identified policies have been at alleviating energy poverty in rural areas. Thus far, the report has identified the ways in which energy poverty is defined (or not defined) in NPA and EU countries, the opportunities for using LCT to address rural energy poverty, and finally the main barriers to doing so, as highlighted across the different strands of the research. Previous sections have pinpointed some of the key criteria for evaluating the success of policies, projects, and practices against the aim of using LCT to address rural energy poverty. These criteria are put to work in this section to evaluate several different policies that the research has identified. The intention here is not to offer judgement on different policies or projects, but to point towards the kind of policy mix that might be required to achieve the twin aims of addressing rural energy poverty and the deployment of LCT in rural areas across NPA and EU countries. As the quote at the beginning of this section illustrates, the required policy mix will not be the same everywhere and at all times, recognising that each NPA and EU state have different 'operational environments', socially, economically, historically, and politically. However, by assessing different policies against the criteria identified in this research, it becomes possible to understand good practice and how it can be replicated across borders, whether these borders are national, municipal, or regional.

The accompanying ***comparative policy and practice matrix*** shows a selection of the different policies that have been identified through the research (see Annex Two). Along the first rows of the matrix are two groups of criteria, the first relating to tackling energy poverty, and the second relating to other criteria that have been identified through the research. Each policy or programme identified by the research is assessed against these criteria. A traffic light system is used to show the status of each policy quickly and easily against the criteria, and a brief explanation is given in each box to describe how each policy/project meets each criteria.

The criteria have been chosen based on the research presented in the preceding sections and are discussed individually in the next sub-section. Following this, a commentary is provided on the key insights from the policy and practice matrix. It should be noted that this matrix is not definitive, and does not cover every policy, project, or practice from the NPA or EU. It focuses on those that are most linked to LCT and energy poverty, such as those which aim to facilitate the replacement of fossil fuel heating systems with low-carbon alternatives or support broader shifts towards renewable energy in rural areas. As a result, it does not consider policies such as those that protect against self-disconnection, or more general social security/income support schemes. Furthermore, it considers where possible policies that have been active within the last three years, although some that are older than this are included where they are judged to be particularly noteworthy.[68]

Establishing the criteria

The first four criteria in the matrix relate the evidence collected on what shapes the success of LCT policies in addressing rural energy poverty. These are:

> **Affordable:** To what extent does the policy enable rural energy poor households to be able to afford the relevant LCT?
>
> **Accessible**: To what extent is the policy simple to access and understand for rural energy poor households?
>
> **Holistic**: To what extent does the policy include or enable other measures to tackle rural energy poverty, such as insulation, remedial measures, or energy advice/support?
>
> **Rural**: To what extent does the policy consider and respond to the specific characteristics and challenges of rural energy poverty?

In addition, the following three criteria have been identified by the research as important to shaping the success of LCT policies/projects in addressing rural energy poverty. These are:

> **Multiple technologies**: To what extent does the policy incorporate a mixture of LCTs, in the recognition that a 'one-size-fits-all' approach to technology is unlikely to be suitable in all rural cases?
>
> **Subnational partners**: To what extent does the policy enable the meaningful involvement of subnational and/or community partners at local, municipal, and/or regional scales?
>
> **Long-term**: To what extent is the policy characterised by long-term certainty, including long-term funding?

It should be underlined that these criteria are not presented as definitive markers against which to conclusively assess the success or failure of different policies or projects. Indeed, as the accompanying policy and practice matrix makes clear, it is not possible for one policy or project to address all of these issues simultaneously. Instead, these criteria are offered more as heuristic devices that enable a high-level assessment of different policies/projects across the NPA and EU, with the broader aim of highlighting the gaps and different kinds of policy mix that might be required to address rural energy poverty with LCT in different countries.

Key insights

In most cases, funding for 100% of installation costs is not provided. For low-income and energy poor households in rural areas, this was identified as one of the major barriers to the uptake of LCT. National policies in the UK, Ireland, France, and Poland were identified that contribute full installation costs and other incentives to encourage uptake by low-income households, but the majority of other policies have a cap (either percentage contribution or capital ceiling) on the amount that can be provided to households. As noted in Section 4.1., this makes it difficult for energy poor households to afford the full cost of LCT, and creates challenges for other important actors, such as landlords and delivery organisations.

Almost none of the identified policies incorporated detailed energy advice and support as part of a holistic rural energy poverty offering. Encouragingly, many of the heating system installation policies examined as part of this review include whole house retrofit and insulation within their scope, and others also included broader measures that may benefit rural energy poor households, such as sewerage or microgeneration opportunities. However, there is little evidence that the kinds

of advice, support, and wraparound care highlighted in this research is present in LCT policies, with only two examples identified in Scotland and Ireland (see Case Study Three). This points to the case for replicating models such as the One Stop Shop, discussed in Section 3.2., and linking them more strongly to LCT installation policies and programmes.

There is limited evidence of rural targeting or of policies being adapted to the characteristics of rural areas. This research has identified how the specific characteristics of rural areas, irrespective of national context, shape vulnerability to energy poverty. However, there is limited evidence that any national LCT policies or programmes specifically target rural energy poverty or feature adaptations to increase the likelihood that they will be accessible to rural energy poor households. Two exceptions here are Cyprus' solar scheme, which doubles the amount of grant available to households in mountainous areas, and Estonia's Sparsely Populated Programme, which is targeted specifically at rural areas. Beyond this, it seems that national policies are more inclined to apply an approach that does not sufficiently consider how programmes may need to be adapted to better benefit rural communities, even in cases where funding is targeted to rural communities.

There is also limited evidence on the extent to which national LCT policies incorporate subnational or community partners. For the most part, subnational involvement in national policy tends to be through local, regional, or municipal government actors. However, there is limited evidence of national policy that attempts to link together LCT, energy poverty, and community energy (but see Case Study Three for an example of where this has been done). It may be that different local, regional, or municipal government actors engage community partners, such as in the cases of Estonia and Poland, but it has not been possible to verify this in this research.

There are examples of policies which can be defined as long-term, as well as policies which arguably fall into the 'stop-start' category discussed as problematic by CfE respondents. Specifically, the evidence seems to point towards policies that are renewed for short periods of time and then reviewed before any extension, reformulation, or cancellation is decided upon. While schemes must remain responsive to broader political national and supranational contexts, this was precisely what CfE respondents, particularly those who provide advice and support to rural energy poor households, described as 'stop-start' funding, which provides little certainty, confidence, or longevity for rural households, communities, and service providers.

It is unlikely that individual policies can meet all of the criteria identified in this research. The key objective for NPA and EU actors must be to coordinate and integrate a bespoke energy poverty and LCT policy mix which, as a whole, meets the criteria to the greatest degree possible. Such an approach would maximise the possibility that LCT can be deployed successfully in a way that simultaneously addresses rural energy poverty. This policy mix should ideally:

- Include provision for 100% of total LCT heating system installation costs for rural energy poor households. Ideally, this should also include the cost of insulation/retrofit measures if they are deemed to be suitable for a specific household.
- Be as simple as possible for low-income, vulnerable, and energy poor households to access, whether through streamlined application processes or third-party mediation (e.g. through housing associations, referral through healthcare professionals).
- Include holistic provision for insulation/retrofit measures, advice on LCT installation and optimal operation, and broader energy related-advice and support (on e.g. debt, supplier switching, energy efficiency).

- Include mechanisms to adapt funding streams, targeting, support, accessibility, and installation processes to the specific characteristics of rural, remote, and island areas in each NPA or EU state. This should not be prescriptive, but should be based on a detailed analysis of the challenges faced by specific rural communities, followed by an assessment of how the policy mix can, as a whole, address these challenges.
- Include provision for a mixture of technologies, not a single technology.
- Include a strategy for engaging with subnational and community partners, and for developing community energy, which may be essential to reaching the most vulnerable households in rural communities and maximising the benefits of LCT to rural areas.
- Plan to have as great a degree as possible of long-term stability and certainty, to provide all actors involved with confidence.

How this can be achieved is beyond the scope of this research, but these criteria and the policies identified in the matrix provide a starting point from which policy development across the NPA can be considered and explored. In addition to the comparative policy matrix, the case study below of Ireland's Community Energy Grant scheme can be considered a good example of a policy which links most, but not all, of the seven criteria.

Case Study Three: The National Retrofit Programme Community Energy Grant 2021

The Community Energy Grant is part of the Irish Government's National Retrofit Programme, which is managed by the Sustainable Energy Authority of Ireland (SEAI). It aims to upgrade housing stock, install renewable energy heating systems in homes, and reduce fossil fuel usage, energy costs, and greenhouse gas emissions. The scheme is premised on the notion that "*by bringing together groups of buildings under the same retrofit programme, communities projects facilitate community-wide energy improvements more efficientlyy and cost effectively than might otherwise be possible*." Moreover, it has a focus on energy poverty, offering up to 80% of the cost for energy poor homes and working with applicants to secure funding to cover the remaining 20%. The main characteristics of the scheme are below.

Affordability	Up to 80% of funding is provided for private energy poor homes, but there is an expectation that consortiums can leverage alternative sources of funding (e.g. social finance) to cover the difference in cost.
Accessibility	The programme is deliberately designed to enable community organisations, housing associations, local authorities, and other subnational actors to identify and support energy poor households to access the scheme.
Holistic	The programme aims to develop community linkages with One Stop Shops, as well as supporting the growth and scaling up of existing One Stop Shops.
Rural	The programme does not have a specific focus on rural areas or communities.
Multiple technologies	Different combinations of insulation, energy-smart walls and doors, renewable energy solutions (wind, biomass, solar PV and thermal), energy efficient lighting, microgeneration, smart metering, and heat recovery solutions are available as part of the scheme.
Subnational partners	The programme aims to empower local businesses, public sector organisations, housing associations, local authorities, and community groups to lead deep energy efficiency upgrades on the buildings and housing stock under their control, or in their region. Further, it aims to develop community skills and empower communities to lead small to medium scale projects.
Long-term	The 2021 programme follows on from the 2020 programme, but there is no further information provided on the future of the scheme. However, it is intended to support targets to retrofit 500,000 homes to a Building Energy Rating of B2 and to install 400,000 heat pumps in existing buildings in Ireland by 2030.

In the previous iteration of the scheme in 2020, it supported energy efficiency upgrades in 656 homes to a B2 standard, and since its inception, the scheme has supported upgrades in 18,856 homes. The strength of the programme is the way it blends a strong focus on communities, a non-prescriptive attitude towards eligible technologies, and incentives to make the scheme accessible and affordable for energy poor households. However, it does not have any specific focus on rural households or the nature of rural vulnerability, and the programme is reviewed and amended on an annual basis.

6. Conclusions

A recent EU document states that, across Europe, 130 million people live in rural areas.[69] The available evidence suggests that 1 in 5 households across the EU may be living in energy poverty, affected as they are by higher rates of energy expenditure.[70] The need to decarbonise domestic energy consumption in rural areas while simultaneously addressing energy poverty is therefore a critical challenge facing policymakers, practitioners, and other actors across the whole of Europe.

This aim of this report was to conduct a policy review of approaches and barriers to tackling energy poverty across the NPA region, and to identify and assess policy initiatives that could enable countries in the NPA region to address energy vulnerability and energy poverty across rural, remote, and island areas. The report has been split into four main sections, covering: a) the ways that fuel poverty and energy poverty are defined in the NPA region and wider EU, b) opportunities for implementing LCT to address rural energy poverty, c) barriers to implementing LCT to address rural energy poverty, and finally d) an assessment of relevant policies and projects, based on criteria identified throughout prior sections. This section distils the key findings from the research, and offers some final thoughts on the dual challenges of decarbonisation and tackling energy poverty.

Key findings

The key findings from this programme of research are as follows:

There are differences in how energy poverty is defined, measured, and utilised in practice across the NPA and wider EU. In the UK, which has a longstanding history of defining and measuring fuel poverty, different variations and evolutions of the 10% definition are used, whereby households required to spend more than 10% of their household income to maintain a satisfactory heating regime are defined as being fuel poor. However, the evidence suggests that the 10% definition has significant limitations, and is typically not used in practice by organisations offering support to households across the UK. In recognition of these limitations, proposed definitions in the Netherlands and wider EU have begun to develop multi-indicator definitions of energy poverty, whereby income, energy costs, and energy efficiency take their place among a suite of broader indicators, such as indebtedness, ill-health, and presence of damp/rot/mould in a home. The proposed strength of these indicators, it is argued, is that they better reflect how energy poverty is encountered and addressed 'on the ground', as well as how it is lived and experienced by households. Lastly, despite this, there is evidence that formal definitions and metrics for measuring energy poverty are considered less relevant in other NPA and EU countries, especially those that have specific socio-historical, cultural, and social welfare contexts, such as Finland.

The specific characteristics of rural areas exacerbate vulnerabilities to energy poverty in complex ways. The research has identified six common characteristics of rural areas that can exacerbate energy poverty: lower income relative to urban areas; limited connectivity (digital, transport, and social); limited access to services; old and hard-to-treat housing stock quality; socio-demographics, especially aging populations; and the greater prevalence of more extreme weather conditions. These characteristics are not homogenous across all rural areas, and different combinations of each will be more or less prevalent depending on where exactly is under consideration. Furthermore, these characteristics fundamentally shape which technologies and other measures can be effective in addressing rural energy poverty and the likelihood of uptake among households.

Holistic energy poverty offerings may be required to decarbonise rural homes in a way that is most beneficial for low-income and vulnerable households. At its broadest, the holistic energy poverty

offer can be defined as one that combines the installation of LCT with other, related services to maximise the positive impact on energy poverty in rural areas. Prominent among these services were, firstly, the provision of energy-related advice and support, to help rural energy poor households obtain the optimal mix of technologies that is best suited to their needs, to guide them through the installation process, and finally to support them with any other associated issues related to health, indebtedness, and/or energy market engagement. Secondly, the evidence highlighted the importance of the parallel provision of remedial works to a property, such as insulation, draughtproofing, and damp/mould removal. The holistic energy poverty offer would therefore be one where the home is looked at as an integrated whole, encompassing the physical property and the specific way it is inhabited, and this constitutes the starting point for a consideration of what combination of advice/support, LCT, and remedial measures might have the greatest impact on energy poverty.

The research has identified different examples of business models that can be effective in decarbonising rural energy consumption while reducing energy poverty. Specifically, different types of community energy models have been shown to facilitate inclusive organisational and governance structures, (re)investment of profits into local energy poverty initiatives, greater energy market engagement among energy poor members of local communities, and finally stronger links between rural communities and other relevant actors concerned with reducing energy poverty, such as local/municipal authorities or social housing operators. In addition to this, several other innovative and interesting models and cases have been uncovered throughout the research which provide some good practice examples and opportunities for transferability and learning within and across NPA and EU states.

Three key barriers to the uptake and implementation of LCT in rural areas have been identified: funding challenges, policy and scheme complexity, and challenges in raising awareness and the related role of trust. Firstly, a lack of long-term policy and funding from national and supranational governments was highlighted as a significant barrier to encouraging the uptake of LCT in rural areas, often because the cost of survey and installation is high and cannot be met by low-income, energy poor households, landlords, or scheme delivery organisations. Secondly, policies and schemes were also described as complex to understand for low-income and vulnerable households, sometimes in conflict with other governmental priorities, or not designed with beneficiaries in mind/the views of potential beneficiaries included through consultation processes. Finally, a significant barrier remains relatively low public awareness of LCT as a heating solution in some NPA and EU countries, and the related challenge of funding schemes being accessible to, and considered trustworthy by, rural communities. Accordingly, it is possible that specific or enhanced regulations and consumer protections may be required to achieve higher levels of trust, confidence, and protection in LCT programmes.

Drawing on the above findings, the research has suggested seven criteria that can be used to provide a heuristic, high-level assessment of policies relating to energy poverty, energy efficiency, and/or LCT.

> **Affordable:** To what extent does the policy enable rural energy poor households to be able to afford the relevant LCT?
>
> **Accessible**: To what extent is the policy simple to access and understand for rural energy poor households?

Holistic: To what extent does the policy include or enable other measures to tackle rural energy poverty, such as insulation, remedial measures, and/or energy advice/support?

Rural: To what extent does the policy consider and respond to the specific characteristics and challenges of rural energy poverty?

Multiple technologies: To what extent does the policy incorporate a mixture of LCTs, in the recognition that a 'one-size-fits-all' approach to technology is unlikely to be suitable in all cases?

Subnational partners: To what extent does the policy enable the meaningful involvement of subnational and/or community partners at local, municipal, and/or regional scales?

Long-term: To what extent is the policy characterised by long-term certainty, including long-term funding?

An assessment of selected existing or recent national policies from across the NPA and EU is provided in the accompanying comparative policy matrix (see Annex Two). The matrix demonstrates that no one policy identified meets all of the above criteria. This suggests that the key objective for NPA and EU actors must be to coordinate and integrate a bespoke energy poverty and LCT policy mix which, as a whole, meets the criteria to the greatest degree possible. Such an approach would maximise the possibility that LCT can be deployed successfully in a way that simultaneously addresses rural energy poverty. This policy mix should ideally:

- Include provision for 100% of total LCT heating system installation costs for rural energy poor households. Ideally, this should also include the cost of insulation/retrofit measures if they are deemed to be suitable for a specific household.
- Be as simple as possible for low-income, vulnerable, and energy poor households to access, whether through streamlined application processes or third-party mediation (e.g. through housing associations, referral through healthcare professionals).
- Include holistic provision for insulation/retrofit measures, advice on LCT installation and optimal operation, and broader energy related-advice and support (on e.g. debt, supplier switching, energy efficiency).
- Include mechanisms to adapt funding streams, targeting, support, accessibility, and installation processes to the specific characteristics of rural, remote, and island areas in each NPA or EU state. This should not be prescriptive, but should be based on a detailed analysis of the challenges faced by specific rural communities, followed by an assessment of how the policy mix can, as a whole, address these challenges.
- Include provision for a mixture of technologies, not a single technology.
- Include a strategy for engaging with subnational and community partners, and for developing community energy, which may be essential to reaching the most vulnerable households in rural communities and maximising the benefits of LCT to rural areas.
- Have as great a degree as possible of long-term stability and certainty, to provide all actors involved with confidence.

Concluding remarks

To end, it is worth reflecting again on the nexus of decarbonisation, energy poverty, and rurality. Across the NPA and Europe, policymakers and practitioners are increasingly asking how energy poverty can be addressed and eliminated during the energy transition, and how vulnerable communities can be supported so that no one is left behind. Rurality and decarbonisation are sometimes themselves thought of as difficult obstacles standing in the path of tackling energy poverty; rural areas, as this report has highlighted, face specific challenges which can exacerbate their vulnerability to energy poverty, and decarbonising rural homes can be costly, complex, and disruptive. However, this report has shown that among the barriers and challenges, there is significant potential for the decarbonisation and energy poverty agendas to be aligned in ways that benefit rural homes and communities. More than this, the research has demonstrated that there are already existing schemes and projects that are pointing the way towards what this alignment could look like. Ultimately, it is hoped that this report provides a useful foundation from which policymakers, practitioners, and other actors can consider how, across the NPA and wider EU, they can work together to develop and replicate these alignments across different contexts and countries, achieving decarbonisation in a way that simultaneously benefits low-income, vulnerable, and energy poor rural communities across the continent.

Annex One: Methodology

To locate appropriate literatures for this report, the following approach was undertaken.

1. A Boolean search was undertaken on Google to locate grey and miscellaneous literatures on rural energy poverty and LCT. This search included different combinations of words such as rural, fuel poverty, low-carbon, energy poverty, and energy efficiency.

   The Boolean search string consisted of variations of the following: "energy" OR "fuel poverty" OR "energy poverty" OR "energy efficiency" OR "heating poverty" AND "rural" OR "rurality" OR "remote" OR "sparsely populated" OR "EU" OR "european union" OR "europe" OR "funding" OR "regional" OR "municipality" OR "region" OR "low-carbon technology" OR "low-carbon" OR "zero-carbon" OR "zero-carbon technology" OR "zero carbon" OR "low carbon" OR "heat pump" OR "solar thermal" OR "solar PV" OR "solar" OR "business model" OR "business models" OR "finance" OR "funding"

2. A search was undertaken of relevant EU and European project databases to locate relevant energy poverty projects at a supranational and member state level. This included searches of the EPOV project database; the European Commission Energy site; the NPA programme site; the EU funding database; and the EU rural energy site.

3. A search of policies and policy documents for each NPA and EU country, including the UK, was undertaken. This used the search functions on official governmental websites and databases.

4. A Boolean search was undertaken on Google Scholar, Web of Knowledge, and Scopus to locate academic literature on rural energy poverty and LCT. This search used the same search string described in point 1.

5. As literature was identified from points 1-4, a snowballing technique was employed, whereby the reference lists of identified literature was surveyed for further relevant documents.

6. Finally, during expert interviewees, the research team were pointed to additional literatures, which were subsequently accessed and considered for inclusion in the review.

This process resulted in a long-list of over 100 possible sources of information. These sources were scanned to judge the extent of their adherence to three key criteria: the extent to which they discussed the prevalence and measurement of (rural) energy poverty; the extent to which they discussed national and supranational policies related to (rural) energy poverty and LCT; and the extent to which they discussed how rural communities can be supported to address energy poverty through LCT intervention programmes. Following the expert interviews, the long-list was returned to in an iterative manner to identify any further sources that could provide additional information on themes discussed by interviewees. The final sources included in the report are listed in the endnotes.

CfE respondents

The CfE was deployed as an online form to collect data on policies and practices that the literature review did not identify, to explore some of the issues identified in the review in more detail, and to gather views from across the NPA and EU on different countries' current practice, policies and areas under development, or in need of further development. In particular, it was designed to identify

examples of business models and innovative solutions tackling energy poverty in rural areas, and opportunities for rural communities to access renewable energy sources and reduce their reliance on fossil fuels.

CfE responses were provided by 33 individuals representing organisations and institutions across the private, public and third sectors. The majority of responses were UK based; however, responses were also received from those representing organisations working across Finland, Ireland, Sweden, Greenland, Faroe Islands, Iceland, Norway, and Denmark. Large and smaller sized organisations working exclusively or in part with rural and remote communities were represented and this included, among others, academics working in Scotland, energy service companies, a local government official in Suffolk England, manufacturers of LCT, an individual working for a charity on the Isle of Wight, England, and a housing and health professional in Iceland. The majority of respondents represented support and advice agencies based in nations of the UK and most organisations described their work with rural and remote communities as part of their wider service offering and not exclusively in such settings.

Interviews

Finally, ten in-depth qualitative interviews were undertaken with 17 experts identified through the evidence review and CfE. Fourteen of these interviewees provided consent to be named in the report and their details are included in the table below. These interviews aimed to explore some the key issues and themes identified in the evidence review and CfE in more detail, and from the perspective of different NPA countries.

Interviewee name	**Affiliation**	**Location**
Alda Marín Kristinsdóttir	Austurbru	Iceland
Anssi Kokkonen	Karelia UAS	Finland
Catherine Savage	Northern Ireland Housing Executive	Northern Ireland
Fiona Shirani	Cardiff University	Wales
Helen Roby	Coventry University	Wales
Jóna Árný Þórðardóttir	Austurbru	Iceland
Kate O'Sullivan	Cardiff University	Wales
Keith Baker	The Energy Poverty Research Initiative (EPRi), Glasgow Caledonian University	Scotland
Lucy Cochrane	Consumer Council for Northern Ireland (CCNI)	Northern Ireland
Marilyn Smith	The Energy Action Project (EnAct)	France
Robert Clements	Northern Ireland Housing Executive	Northern Ireland
Robert Prinz	Natural Resources Institute Finland	Finland
Saija Rasi	Natural Resources Institute Finland	Finland
Terry Waugh	Action Renewables	Northern Ireland

This report would not have been possible without the time offered by these interviewees, and the research team explicitly and gratefully acknowledges their contributions to the research. However, although the testimonies and expertise of these interviewees was central to informing the findings of the research, any and all conclusions drawn by this report are those of the authors and the authors alone.

Annex Two: Comparative policy matrix

Case Study	Country	Areas of focus	Actors	Core target group	Tackling energy poverty				Other requirements		
					Affordable	Accessible	Holistic	Rural	Multiple technologies	Subnational partners	Long-term
Raus aus Öl und Gas für Private 2021/2022	Austria	-Heating system installation	National government	Owner occupiers, building owners, tenants	Covers 100% of cost	Complex application and reimbursement process	Insufficient evidence	Available, but not targeted	District heating connections, heat pumps, other heating types	No evidence	Set to end in 2022
Sanierungsoffensive 2021/2022	Austria	-Retrofit	National government	Owner occupiers, building owners, tenants	Covers up to 30% of costs	Complex application and reimbursement process	Insulation and window replacement scheme	Available, but not targeted	No heating systems included	No evidence	Set to end in 2022
REECL Programme	Bulgaria	-Heating system installation -Retrofit	National government, participating banks, EU	No specific target group	Loan equal to 15% of total cost	Complex application and reimbursement process	Included energy efficiency measures (e.g. windows)	Available, but not targeted	Multiple technologies included	No evidence	Ended in 2018
Programme for the Energy Renovation of Family Homes	Croatia	-Heating system installation -Retrofit	National government	Family homes	60% of costs co-financed	Insufficient evidence	Included energy efficiency measures (e.g. external door replacement) and insulation	Available, but not targeted	Solar thermal, solar PV, heat pump, wood/pellet systems	No evidence	Ran 2014-2020, and extended recently
Installation or replacement of solar water heating systems in existing dwellings	Cyprus	-Heating system installation	National government	No specific target group	Small lump sum towards cost	Insufficient evidence	No further measures included	Grant amount doubles in mountain areas	Solar thermal only	No evidence	Set to end in 2021
Encouragement of the use of RES and Energy Saving in dwellings	Cyprus	-Heating system installation	National government	Vulnerable households	35% of eligible costs	Insufficient evidence	Includes roof insulation	Available, but not targeted	Solar PV only	No evidence	Set to end in 2021
New Green Savings	Czech Republic	-Heating system installation -Renewable energy generation	National government, EU	No specific target group	On average, 30-40% of eligible costs	Insufficient evidence	Includes insulation, RES, greenroofing, and wastewater recovery	Available, but not targeted	Boilers, heat pumps, solar panels	No evidence	Continuous policy, now in third phase (2015-2021)
Building Pool	Denmark	-Heating system installation	National government	No specific target group	Varies, but unlikely to cover 100% of costs	Complex application and reimbursement process	Includes insulation and ventilation measures	Available, but not targeted	Heat pump only	No evidence	Current scheme running to 2026
Sparsely populated programme	Estonia	-Heating system installation	National government, local regional/government	Rural areas	Up to 67% of overall costs	Relatively simple paper/online application to local government	Includes multiple non-energy measures (sewerage, water)	Targeted specifically at rural areas	Solar, wind, and storage technologies	Devolved through local government	Currently closed, but multiple rounds (2018-2021)

Case Study	Country	Areas of focus	Actors	Core target group	Tackling energy poverty				Other requirements		
					Affordable	Accessible	Holistic	Rural	Multiple technologies	Subnational partners	Long-term
Renewable heating support	Finland	-Heating system installation	National government	No specific target group, but implicitly targeted at rural areas	20-25% of overall costs covered, including % of labour costs	Complex application and reimbursement process	Insufficient evidence	Available, but not explicitly targeted	Heat pumps, wood based, solar	No evidence	Insufficient evidence
MaPrimeRénov	France	-Heating system installation	National government	Initially targeted at low-income households, now all property owners	Up to 20,000 Euros for low-income households, and targeted bonuses	Relatively simple process depending on income band	Includes insulation and ventilation	Available, but not targeted	Insufficient evidence	No evidence	Short application windows and no long-term extension
Fragile Communities Program	Iceland	Community development and support through collaborative means	Icelandic government	Smaller villages and remote rural communities	Dependent upon the priorities and actions identified by each participating community	Dependent upon the priorities and actions identified by each participating community	Dependent upon the priorities and actions identified by each participating community	Program is specifically targeted towards rural and remote communities	Specific approach determined by community so may include	Goals and actions are established and enacted by local community	Yes – running since 2012 and has expanded
The National Retrofit Programme Community Energy Grant	Ireland	Community led heating system installation, retrofit, and whole house upgrade	National government, housing associations, community organisations, public sector organisations, local authorities	No specific target group, but has incentive and provision for targeting energy poor households	Covers up to 80% of cost for energy poor homes, with support to bridge the remaining 20%	Mediated through community groups to maximise accessibility	Aims to link to Ireland's network of One Stop Shops	Available, but not targeted	Insulation, renewable energy heating systems, smart meters, and others.	Aimed at community groups, housing associations, and other local actors	Unclear
Warmth and Wellbeing Pilot Scheme	Ireland	-Heating system installation (but note they are gas and oil boiler, not LCT)	National government	Targeted at cold-related health conditions	Covers 100% of cost	Referral system through healthcare providers	Includes insulation and ventilation	Available, but not targeted	Gas and oil boiler only, no LCT	Referral based through local healthcare providers	Pilot scheme
Solar PV and Heat Pump schemes	Malta	-Heating system installation	National government	No specific target group	Covers up to 50% of costs	Insufficient evidence	No further measures included	Available, but not targeted	Separate schemes for solar PV and heat pump	No evidence	Closing 2021
Keep Warm	Northern Ireland	-Retrofit	National government, management agent and delivery partner	Low-income homeowners and private tenants	Covers 100% of costs	Insufficient evidence	Includes free advice, and hot water tank jacket/LED light bulbs	Mid-income single person households have special eligibility if they live in rural area	Does not include provision for heating system replacement	No evidence	Covers 2020-2021
Clean Air Programme	Poland	-Heating system installation	National government, participating banks	No specific target group	Additional 12,000 PLN for low-income households	Simplified application process following earlier rounds	Includes insulation, but with restrictions	Available, but not targeted	Heat pump and solar PV combinations encouraged	Administered through local government units	Has been through multiple iterations

Case Study	Country	Areas of focus	Actors	Core target group	Tackling energy poverty				Other requirements		
					Affordable	Accessible	Holistic	Rural	Multiple technologies	Subnational partners	Long-term
Economic and Social Stabilization Program (PEES)	Portugal	-Heating system installation -Retrofit	National government	No specific target group	Limit on contribution up to 3,000 Euros	Insufficient evidence	Includes renovation measures	Available, but not targeted	Heat pumps, solar, biomass	No evidence	In place 2020-2021
Home Energy Scotland Loan	Scotland	-Heating system installation -Retrofit	Scottish government, managed by Local Energy Scotland	Homeowners, landlords, property developers	Zero interest loans that must be repaid	Made more accessible through advice provision	Includes several additional measures and advice/support	Available, but not targeted	Numerous heating technologies included	Mediated through community development officers and CARES programme	Yes, ongoing
Green Households II	Slovakia	-Heating system installation -Renewable energy generation	National government	Family and apartment houses	Covers 50% of expenditure	Insufficient evidence	No evidence of additional measures	Available, but not targeted	Heat pumps, solar, biomass	No evidence	In place from 2019-2023
Green Homes Grant	UK	-Heating system installation -Retrofit	National government	-Low-income households -All households	Covers 100% of cost for low-income households	Complex voucher application process, but simpler through local authority delivery element	Included secondary energy efficiency measures	Available, but not targeted	Heat pumps, solar thermal, biomass	Local authority delivery element	Local authority delivery continuing
Domestic Renewable Heat Incentive	UK	Funding for renewable sources	National government	Homeowners and private and social landlords	No assistance with upfront install costs	Complex application and payment process	No evidence of additional measures	Available, but not targeted	Heat pumps, solar, biomass	No community or local government involvement	In place since 2014

Annex Three: References

[1] It should be noted that this review identified numerous literatures on the links between energy poverty, rurality, and LCT outside of Europe. Although these literatures were beyond the scope of this review, it is likely there is also much to be learned from LCT policies and projects outside of the European context.
[2] Boardman, B. (1991) *Fuel poverty: from cold homes to affordable warmth*. London: Belhaven Press.
[3] Hills, J. (1992) Getting the measure of fuel poverty: Final Report of the Fuel Poverty Review.
[4] Middlemiss, L. (2017) A critical analysis of the new politics of fuel poverty, *Critical Social Policy* 37 (3): 425-443.
[5] BEIS (2021) Sustainable Warmth: Protecting Vulnerable Households in England.
[6] Welsh Government (2021) Tackling fuel poverty 2021 to 2035; Department for Communities (2011) Warmer Healthier Homes - a new Fuel Poverty Strategy for Northern Ireland.
[7] Welsh Government (2021) Tackling fuel poverty 2021 to 2035.
[8] Liddell, C; Morris, C; McKenzie, P. and Rae, G. (2011) Defining Fuel Poverty in Northern Ireland: A Preliminary Review.
[9] Scottish Government (2019) Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019.
[10] Exceptions to this are in France and Italy, who both have energy poverty observatories that collate and share information on national energy poverty. Italy's energy poverty observatory uses an adjusted 10% definition, while France's energy poverty observatory uses a mixture of indicators, including the need to spend 8% of income on housing bills.
[11] References in this paragraph are from: Middlemiss, L; Mulder, P; Hesselman, M; Feenstra, M; Tirado Herrero, S. and Straver, K. (2020) Energy Poverty and the energy transition: Towards improved energy poverty monitoring, measuring and policy action.
[12] References in this paragraph are from Therna, J. and Vondung, F. (2020) EPOV Indicator Dashboard: Methodology Guidebook.
[13] Constantinescu, T. (2019) Can the EU afford to leave rural areas behind in its energy transition? For a broader discussion of the question of energy poverty measurement in the EU, see Social Watt (2019) Connecting obligated parties to adopt innovative schemes towards energy poverty alleviation: Report on the status quo of energy poverty and its mitigation in the EU.
[14] For example, see Jessel, S; Sawyer, S. and Hernandez, D. (2019) Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature, Frontiers in Public Health. This article posits that "*vulnerable communities often experience energy insecurity bundled with other hardships*", such as health and housing inequalities.
[15] In the Finnish context, this testimony is supported by broader evidence. For example, Finland's (2019) Integrated Energy and Climate Plan states that "*there is not a significant number of households in Finland that would suffer from energy poverty. This is why Finland does not have national objectives related to energy poverty […] energy poverty is still rare, as social security mitigates its effects.*" (p.78-79)
[16] Bredvold, T.L. (2020) "Where no one is poor, and energy is abundant": A study of energy poverty in Norwegian households.
[17] Von Platten, J. et al. (2020) Energy inequality as a risk in socio-technical energy transitions: The Swedish case of individual metering and billing of energy for heating.
[18] EPOV (2020) Member State Reports on Energy Poverty 2019, p.27-30.
[19] Irish Government (n.d.) A Strategy to Combat Energy Poverty, 2016-9.
[20] Scottish Government (2019) Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019.
[21] Department for Communities (2011) Warmer Healthier Homes - a new Fuel Poverty Strategy for Northern Ireland. We note however that Northern Ireland's Department for the Economy released the Energy Strategy for Northern Ireland consultation on policy options, with the plan to have a new Energy Strategy in place by December 2021.
[22] Northern Ireland Housing Executive (2016) House condition survey: main report.
[23] Comhairle nan Eilean Siar (2019) Outer Hebrides anti-poverty strategy 2019-2024, incorporating the local child poverty action report 2019.
[24] Bouzarovski, S; Thomson, H; Cornelis, M; Varo, A. and Guyet, R. (2020) Towards an inclusive energy transition in the European Union: Confronting energy poverty amidst a global crisis.
[25] Scottish Government (2016) Delivering affordable warmth in rural Scotland: action plan.

[26] Scottish Government (2020) The Fuel Poverty (Additional Amount in respect of Remote Rural Area, Remote Small Town and Island Area) (Scotland) Regulations 2020.
[27] Changeworks (2017) District heating: Delivering affordable and sustainable energy.
[28] Climate Change Committee (2018) Biomass in a low-carbon economy.
[29] Climate Change Committee (2018) Biomass in a low-carbon economy.
[30] Rural Energy EU (2020) Future of Rural Energy in Europe: Executive Summary.
[31] For a general overview of the potential role of hydrogen in decarbonising domestic heat, see: Fraunhofer IEE (2020) Hydrogen in the energy system of the future: focus on heat in buildings.
[32] Orkney Islands Council (n.d.) Orkney Hydrogen Strategy: The Hydrogen Islands 2019-2025.
[33] This quote is taken from one of our CfE respondents.
[34] See for example the discussion of the role of advice in LCT installation in Consumer Council for Northern Ireland (2021) Customer experiences of installing renewable technology in Northern Ireland. This research explicitly notes the importance of One Stop Shops to advising households on the best LCT options for their home.
[35] Scottish Government (2019) HES Homecare pilot: evaluation.
[36] Ellsworth-Krebs, K; Reid, L. and Hunter, C.J. (2015) Home-ing in on domestic energy research: "House," "Home," and the importance of ontology, Energy Research and Social Science 6: 100-108.
[37] Martiskainen, M. Heiskanen, E. and Speciale, G. (2018) Community energy initiatives to alleviate fuel poverty: the material politics of Energy Cafes, Local Environment 23 (1): 20-35.
[38] Kirchherr, J; Reike, D. and Hekkert, M. (2017) Concetpualizing the circular economy: An analysis of 114 definitions, Resources, Conservation and Recycling 127: 221-232.
[39] Roesler, T. (2018) Community resources for energy transition: Implementing bioenergy villages in Germany, Area 51: 268-276; Roesler, T. and Hassler, M. (2019) Creating niches – the role of policy for the implementation of bioenergy village cooperatives in Germany, Energy Policy 124: 95-101.
[40] Community Energy Plus (2017) Low Carbon Heat and Rural Fuel Poverty: Lessons from across Europe.
[41] For more on this, see Roby, H. and Dibb, S. (2019) Future pathways to mainstreaming community energy, Energy Policy 135: 111020.
[42] However, we note the new Community Energy for Energy Security project, which is funded under New Horizon 2020 and is due to launch in June 2021. As one interviewee told us, "*it's 9 or 10 different community energy projects that are going to now say, 'How can we adjust our models so that they specifically address energy poverty within the communities?' So, they are already community energy projects and they're trying to say, 'How can we shift our models to consider energy poverty?'* Therefore, although this project has not commenced, it is evidence of a growing concern with linking community energy and fuel poverty.
[43] For an excellent discussion of community energy in the EU, as well as its role in addressing energy poverty, see Friends of the Earth, REScoop, and Energy Cities (2020) Community Energy: A practical guide to reclaiming power, especially Chapter 15.
[44] See for example The CHEESE Project, discussed in a later paragraph.
[45] Wilkins, D.J; Chitchyan, R; and Levine, M. (2020) Peer-to-Peer Energy Markets: Understanding the Values of Collective and Community Trading.
[46] See for example the collaboration between Energy Cloud, Ulster University, and the Spire 2 – RULET initiative, to provide excess wind power to energy poor homes.
[47] Written evidence submitted by Ripple Energy Ltd to the UK Government's enquiry on community energy.
[48] See for example the services offered by the Brighton and Hove Energy Services Cooperative in England.
[49] As discussed by one interviewee.
[50] Written evidence submitted by Electricity North West to the UK Government's enquiry on community energy.
[51] As discussed by one interviewee.
[52] As discussed by one interviewee.
[53] Nolden, C; Rossade, D. and Thomas, P. (2021) Capturing the value of community fuel poverty alleviation.
[54] See the collaboration between Energy Cloud, Ulster University, and the Spire 2 – RULET initiative, to provide excess wind power to energy poor homes.
[55] Written evidence submitted by Ripple Energy Ltd to the UK Government's enquiry on community energy.
[56] Community Energy Plus (2017) Low Carbon Heat and Rural Fuel Poverty: Lessons from across Europe.
[57] Common Weal Policy for Calor (2019) Carbon-free, poverty-free: Heating options for rural Scotland.

[58] Centre for Sustainable Energy (2018) Bringing local energy benefits to deprived communities.
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[62] Department for Business, Energy and Industrial Strategy (2020) Transforming heat – public attitudes research; Energy Systems Catapult (2020) Public awareness of and attitudes to low-carbon heating technologies: An evidence review with primary focus on domestic consumers in Scotland.
[63] Karytsas, S. and Theodoropoulou, H. (2014) Public awareness and willingness to adopt ground source heat pumps for domestic heating and cooling, Renewable and Sustainable Energy Reviews 34: 49-57.
[64] Community Energy Plus (2017) Low Carbon Heat and Rural Fuel Poverty: Lessons from across Europe.
[65] See CRESR (2019) Reaching the 'Hardest to Reach' with energy advice: final report.
[66] On which see the energy café approach discussed in Martiskainen, M. Heiskanen, E. and Speciale, G. (2018) Community energy initiatives to alleviate fuel poverty: the material politics of Energy Cafes, Local Environment 23 (1): 20-35.
[67] This quote is from one of our expert interviews.
[68] For an earlier catalogue of EU wide policies relating to energy poverty, see: EPOV (2020) Member State Reports on Energy Poverty 2019.
[69] Rural Energy EU (2020) Future of Rural Energy in Europe: Executive Summary.
[70] Bouzarovski, S; Thomson, H; Cornelis, M; Varo, A. and Guyet, R. (2020) Towards an inclusive energy transition in the European Union: Confronting energy poverty amidst a global crisis.