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Review

Who applies for energy grants?

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ABSTRACT

Most domestic energy retrofit policies in the UK are designed to incentivise economically rational consumers. Logically, this should mean that applicants to domestic energy incentives are those who can financially benefit the most from these subsidies. Here, we test this logic by asking the question 'what types of households apply for domestic energy incentives in the UK?'. To answer this question, we systematically assess the characteristics of households who apply for incentives and develop a GB neighbourhood level household typology bringing together data sets on domestic energy incentives and household geo-demographics.

We discover that some types of households are much more likely to apply for incentives than others. In particular, we find that Asian origin, owner-occupier households of low income living in energy inefficient terraces apply for ECO incentives at a rate twelve times higher than expected. This phenomenon is even more pronounced when we look at applications by geographic area, with these households applying in very high numbers in the industrial north of England.

Building on recent work on energy consumption and social relations, we argue that understanding the increased likelihood of these household types to apply for domestic energy incentives demands a *relational* perspective. These households share geo-demographic and dwelling characteristics, which suggests the spread of uptake of policy through the community through networks of social relations, as opposed to uptake purely on the basis of perceived cost-benefit. We conclude by offering insights for policy makers about the possibilities for mobilising social relations in the delivery of energy efficiency projects.

1. Introduction: a story of unexpected findings

Successive UK governments have offered a range of domestic energy incentives to householders. These incentives include grants, loans and revenue payments (e.g. Feed-in-Tariffs) to subsidise energy efficiency, micro-generation and storage solutions that reduce both operational costs and greenhouse gas emissions. Some of these incentives are aimed at wealthy households who are looking to invest in relatively efficient homes; others are targeted towards low-income households living in inefficient homes which can be made more efficient. To date, limited analysis has been undertaken, by government or by researchers, as to who applies for domestic energy incentives, and indeed who does not [1–3]. In this paper we bring together geo-demographic and domestic energy incentive data sets, to answer the question 'what types of households apply for domestic energy incentives?'. This helps us to identify factors beyond efficiency of the home and level of income that can explain incentive uptake.

In the UK there is a widespread concern that domestic energy incentives do not adequately target the fuel poor: in 2016 only 10 % of Energy Company Obligation (ECO) grants were thought to be received by fuel poor households, rising to only 30 % in 2020 [4]. Further, the funding of domestic energy incentives through levies on energy bills is regressive: when costs are applied universally across households, poorer households pay a greater proportion of their income towards this policy [5]. The question of what types of households apply for domestic energy incentives is therefore really about the fair distribution of government resources. In order to achieve a fair distribution, UK government often establishes capital grant or subsidy schemes which are operated on a first-come first-served basis and limit the grant allocation year on year (e.g. ECO). Kerr et al. (2018) [6] describe an academic debate which

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regards such policy interventions in retrofit as based on a rational choice approach to decision making. In this conceptualisation actors are rational and self-seeking. With sufficient agency they will apply for subsidies or grants which improve the cost benefit ratio of retrofitting their homes.

Rational choice explanations of energy related behaviour are widely questioned in the literature, particularly by scholars from beyond the disciplines of economics and psychology [7–12]. Some scholars expand the definition of rationality and develop solutions in 'behavioural economics' [13,14]. Others refute individual framings altogether and propose other sociological theories of change such as social practice theory [15,16]. Nevertheless, UK government policy continues to design schemes based on rational choice assumptions, addressing individual home-owners with capital subsidies for projects aimed exclusively at reducing energy bills and saving carbon [17]. Only behavioural economics has had some heterodox influence on the UK's Department for Business, Energy and Industrial Strategy[1] (BEIS) (See: Behavioural Insights Team (2011) [18]), and little of the various social insights developed in the literature have had a shaping influence on policy.

The paper emerges from a conversation in our interdisciplinary team of energy social scientists, active on a funded energy efficiency retrofit research project. We initially assumed that social class would offer more explanatory power than rational choice: with a theory that 'sharp-elbowed middle classes' were more likely to apply for incentives [1,2]. This is not an unreasonable assumption. Indeed, in existing studies in Australia [19] and in the US [20] this seems to hold true. Our starting point here was *relational*: we assumed that people's class position and their social and cultural capital influence the resources (domestic energy incentives) they are able to access [21,22]. Applying for grants requires high levels of social capital and personal agency, including skills, affiliations and circumstances: knowing that the grant exists, being able to get quotes to have work done, to fill in a form, and having the choice to make changes to your property. These skills, affiliations and circumstances would seem to be more available to middle-class people in the UK, who tend to have stronger social capital (particularly, links to non-intimate others) [21,23], and the time, agency, money and skills which make applying for a grant relatively easy in comparison to other social groups.

In the end, neither the 'sharp-elbowed middle classes', nor the 'rational choice' assumptions, offered adequate explanations for the patterns we uncovered in the data. Instead, a different relational pattern emerged, in which specific geo-demographic groups were more likely to apply for domestic energy incentives than others. The most unexpected of these was a large cluster of low-income Asian-origin households living in terraced housing, who are twelve times more likely to apply for ECO than we would expect given the overall share of household in the UK of this type. This phenomenon is most prevalent across the North of England, and occurs across a range of local authority jurisdictions in ex-industrial cities. This suggests that the phenomenon is not due to local authority targeting, but is instead due to some kind of social transmission within Asian communities, living in high-density and energy inefficient housing.

We begin by outlining the key domestic energy incentives in the UK since 2010, and explaining how funds were distributed. We then articulate what this implies about what types of household apply for energy incentives, showing the limitations of rational choice explanations, and introducing relational approaches. Drawing on data from household energy performance certificates and the UK Census, we then look to answer our question of 'what kinds of household apply' for these incentives empirically. We find a number of patterns which are not easily explained by theories based in rationality, including a large cluster of applicants from low-income Asian-origin households living in terraced housing in cities located across Northern England. We use a relational approach to explain the uptake of domestic energy incentives according to these geo-demographic patterns. We also comment here on the relative sparsity of research on ethnicity and energy consumption, (though see: Bouzarovski et al., 2022 [24]) recommending that more attention is paid to this in future. We conclude by discussing the implications of this explanation for domestic energy policy.

2. What do we know about (applicants to) domestic energy incentives?

We investigate four[2] key domestic energy incentive policies, aimed at promoting retrofit in domestic buildings, which have played a major role in reducing the UK's energy use and greenhouse gas emissions in the last decade [25]. Total UK household energy consumption decreased by 18 % between 2002 and 2020 on a temperature corrected basis, despite increases of 12 % in the number of households and 13 % in UK population over that period [26]. The corresponding change in GHG emissions from domestic home heating between 2002 and 2020 shows a reduction of 13 % [27].

Table 1 provides a summary of the key domestic energy incentives since 2010 in the UK. We then briefly introduce each policy, outlining how it was targeted, articulating the rationale behind the incentive, and showing how applicants are expected to act in response to incentives.

2.1. Key domestic energy incentives in the UK 2010–2022

'Supplier obligations' allow governments to provide domestic energy incentives to households - recovering the costs from a levy on household gas and electricity bills. These have been in operation since 1994 in the UK. The Energy Companies Obligation (ECO) was introduced in 2013, and has since been the mainstay of domestic energy efficiency policy in Great Britain,[3] providing over 3.3 million measures to 2.3 million homes [28]. In 2022, ECO is in its fourth iteration, and has seen significant shifts in target demographic and measures funded during this period. ECO has moved away from the wide scale delivery of single measures to both fuel poor and 'able to pay' homes to a much smaller, concentrated programme that focusses on more extensive retrofit of fuel poor and energy inefficient homes. Funding has also varied during this period.

Grant applications are assessed by a combination of household means-testing and energy efficiency assessments. The motivation for the applicant to apply is the availability of financial support to achieve a more comfortable and cheaper-to-run household. The applicant is expected to respond to the financial support available by applying for ECO to cover some or all of the costs that they will incur in improving their home.

The UK's Green Deal was introduced with ECO in January 2013, targeted at the 'able to pay' segment, and allowing a wider range of measures such as water efficient taps and solar blinds [34]. The Green Deal was a private financing mechanism which used the electricity bill as a repayment channel for loans that could be taken out by households to cover the costs of a range of measures [35]. Households would "pay as they save", with monthly repayments limited to below the predicted bill savings – known as the "golden-rule". Most homeowners were eligible, with only those with the worst credit ratings excluded.

The Green Deal delivered far less than targeted by government. While 614,383 Green Deal Assessments were lodged by the end of October 2015 [36] just 14,000 installs were completed by 2016[4] [31]. This policy was discontinued in 2015. The Green Deal applicant is

[1] Superseded by Department for Business and Trade, Department for Energy Security and Net Zero and Department for Science, Innovation and Technology

[2] We focus on ECO, FiT, RHI and GD because further data on the households who apply for these incentives can be extracted from the EPC database

[3] Northern Ireland has a different policy framework

[4] BEIS estimates that a further 35,000 households have paid for measures following a Green Deal assessment (NAO 2016)

Table 1
Summary of ECO, GD, FiT and RHI domestic energy incentives in the UK 2010-present.[a]

Domestic Energy Incentive	Dates of scheme	Target population	Work funded	Funding	Number of measures
Energy Companies Obligation (ECO)	2013–2015 ECO1 2015–2018 ECO2	People in hard-to-treat properties, all incomes. Low-income households, minimal funding for wealthier households.	High-cost measures (e.g. solid wall insulation)	£920 mill / year (levy on energy bills) £600 mill / year (levy on energy bills)	3.3 million measures to 2.3 million homes [28].
	2018–2022 ECO3	Low-income households in least efficient properties.	27 % of measures gas boiler installs [29]	£640 mill / year (levy on energy bills)	
	2022- ECO4	Low-income households in least efficient properties [30]	Limits on gas boiler installs; upgrading off-grid homes & other innovations; place-based measures encouraged.	£1 bill / year (levy on energy bills)	
Green Deal (GD)	2013–2015	'able to pay', or able to borrow to fund measures	Wide range of measures	Financed by loans accrued by homeowner, paid back through electricity bill.	14 k measures installed [31]
Feed in Tariff (FiT)	2010–2019	People able to invest up front.	Renewable and low-carbon electricity generation	Levy on energy bills	6.2GW of installed renewable capacity, about 900,000 solar PV installations [32]
Renewable Heat Incentive (RHI)	2014–2022	People able to invest up front.	Low-carbon heat generation	Levy on energy bills	98,375 installations by December 2021 [33].

[a] The Green Homes Grant was also implemented in this period, but the programme did not require an update to the EPC certificate and therefore did not appear in the EPC database, our primary source for the study.

someone that understands energy retrofit as a long-term financial investment in their home, irrespective of how long they expect to live in it. They are also someone who is willing and able to borrow money to make energy-related improvements. This frames energy retrofit for the applicant as investment in an asset (the home) with a long payback period.

The Feed in Tariff (FIT) policy was active from 2010 to 2019, providing financial support for small-scale (up to 5 MW) renewable and low carbon electricity generating systems across the UK. The FIT was designed to provide generators a premium above the wholesale price for electricity generated from these sources. FIT generators received support for between 10 and 25 years, depending on technology type [37]. The FIT was paid for by energy suppliers through a levy to electricity bills . By creating long-term certainty around the "payback" of micro-generation, the FIT is generally credited with creating a boom in the UK's rooftop solar market, as well as the community energy sector [38].

The FIT required people to fund the capital outlay for a renewable energy installation themselves in return for a long-term revenue payment for power generated and/or exported. In effect, the incentive was designed to appeal to the reluctant investor in renewables, by reducing the pay-back period of the generation technology. Household applicants were typically relatively wealthy, with capital to invest upfront in the technology [39]. From 2012, households were required to have an up-to-date EPC certificate at band "D" or better, leading to incentives being received by those already living in efficient housing. By providing stable returns to those with spare capital to invest, returns subsidised by all bill payers, some have criticised the initiative as a regressive 'middle-class subsidy' [1–3]. Existing studies show that household level FIT have benefited more affluent socio-economic groups, while FIT claimed by community groups actually consistently benefited areas of higher deprivation [1]. Previous studies associate the take-up of FIT with having the capital to invest [1] and with social class [3].

The UK's Renewable Heat Incentive (RHI) is similar in design to the FIT, but incentivises the installation of renewable heat systems. Introduced in 2014, the RHI provides a £/kWh rebate for renewably generated heat, from a range of system types including biomass boilers, heat pumps and solar thermal technology, with differing rates dependent on the technology. In Northern Ireland, a cap on the total subsidy that applicants could receive led to a rush for applications and the "cash for ash" scandal [40]. By the time of its closure to new participants in Northern Ireland in 2016 [41], the scheme "had a projected overspend on £700m over its 20-year lifetime". For the rest of the UK, applications for both the domestic and non-domestic scheme had closed by the 31st of March 2022, and will be partially replaced by the Boiler Upgrade Scheme (BUS) [42].

RHI presents a similar experience for the applicant as FIT. Again this is likely to have incentivised wealthy but reluctant investors: those that have capital to invest up front, but who are not doing so at the time the incentive is available.

2.2. What type of household would we expect to apply for grants?

All the recent domestic energy incentives in the UK outlined above start with a basic assumption that the homeowner exercises rational choice in applying for energy incentives. Rational choice is rooted in the disciplines of economics, technology application or psychology [6,43,44]. In this perspective, the question of who would be expected to apply for incentives, has a rather simple answer: anyone who is appropriately incentivised. This makes for a rather weak explanation: given that in theory everyone can be incentivised. As a result, such an approach is unlikely to consider the more social and spatial patterning of applications for incentives. Indeed, before we started the analysis for this paper, we were not aware of any research or government reporting that assessed how the uptake of these schemes is distributed either socially or spatially.

The specific rationality expected in these policies is either that the household is 'able to pay', but reluctant to take financial risk (GD, FiT, RHI, early iterations of ECO) or unable to pay (i.e. fuel poor) and in need of financial support (later iterations of ECO). Policies are also built on assumptions that the household is able to unilaterally make the decision to apply for the subsidy and install energy measures. This is typically true for freehold owner-occupiers but is much more challenging for leaseholder, private-rental or social housing occupants, who do not normally have the same freedom of decision making about changes to the property. Domestic energy incentives are designed on the assumption that homeowners are operating as atomised and autonomous individuals, not addressing households in social and spatial context [16,45]. Instead, in this tradition, we might look for 'barriers to uptake' of incentives: anything that inhibits rational investment in efficient technologies [46].

So which type of household would we expect to apply for these incentives following a rational choice logic? The main characteristic we could expect is that those that apply are primarily motivated financially: by saving money through low-risk investment in energy improvements. The specific motivation is slightly different for each of the incentive schemes. For instance, for some schemes applicants must have money to invest (FIT, RHI) or to be in a position to borrow money to spend (GD). We would expect these households to be wealthier than average. For other schemes, especially later iterations of ECO, households must be able to see the financial value (in the promise of lower bills) of making changes in their home. None of these characteristics enable us to anticipate which types of households are more likely to apply for incentives and which will not, or to explain why that is the case.

A further socially and spatially contextual set of explanations for who applies for energy incentives, could come out of recent work in the energy social sciences which offers relational explanations of energy demand behaviours [47]. In this approach, authors argue that people do not consume as untethered individuals: in fact much energy consumption is undertaken in homes, workplaces and communities where existing social relations shape the way in which people use energy (ibid.).

Hargreaves and Middlemiss [47] characterise social relations as consisting of three types of relationship: 1) those with family and friends (for example Bell et al., 2015 [48]); 2) with agencies and communities (for example de Wilde, 2019 [49]); and 3) those associated with social identities (for example Hansen et al., 2019 [50]. Each of these types of affiliation can impact on how people consume energy and how they take up energy policy. From this perspective, people are more likely to apply for domestic energy incentives if, for example: a) family or friends have positive experiences of applying; b) institutional actors within their community (whether community of place or community of interest) help people to see the benefits of such schemes; or c) people have an identity (e.g. environmentalist, frugal consumer) that makes them more likely to be able to apply and to be interested in applying.

This final point brings us to the topic of ethnicity: a much-neglected area of study within energy policy [51] despite long-standing evidence of its significance for understanding the social world [52–55]. Literature at the intersection of energy consumption and ethnicity is scant; however, there is a strong recognition that investigating the intersectionality of social inequality in households is essential to better understand residential energy dynamics [56,57]). MacGregor et al. (2019) [58] show that most UK based policy literature focusing on ethnic minorities' (lack of) engagement in sustainability is due to limited access to information. Local authorities and service providers have often situated minorities within ‘hard to reach’ groups because of socio-cultural, linguistic, and economic reasons, and due to scarce civic participation [59]. The broader environmental justice [60,61] and energy justice literature [62,63] portrays disadvantaged social groups, including people from ethnic minorities, as socially marginalised, and more likely to be subject to environmental harm. Bouzarovski et al. (2022) [24] found patterns of marginalization, precarity and exclusion present across ethnic minority communities, which led to disproportionate impacts on energy vulnerability. The evidence on ethnicity to date has largely focused on the environmental ills facing people from ethnic minorities, and the risks that this entails in relation to energy vulnerability. A relational explanation of the potential for ethnicity to play a role in access to energy incentives, would focus on how the patterns of social relations associated with belonging to a specific ethnic group might enable people to apply for, and access these incentives.

3. Data and methodology

This study aims to answer the question ‘what types of households apply for domestic energy incentives?’ by combining data about applications for DEIs from the Energy Performance Certificate repository with further geodemographic data from the UK Census 2011 and the Indices of Multiple Deprivation 2019. We aim to develop a typology which reveals how likely, or unlikely a particular household type is to apply for a DEI.

3.1. Datasets

One of the key requirements for domestic energy incentive eligibility is having an up-to-date EPC.[5] EPCs were first introduced in England and Wales in 2007 as part of Home Information Packs (HIPs) [51]. HIPs are no longer a requirement for buying and selling a home but it is legally required in the UK to have an in-date EPC[6] in order to build, sell or rent a property. The Department for Levelling Up, Housing and Communities provides free access to EPC certificates for all buildings in England and Wales from 1st October to 2008 to 31st March 2022[7] [64]. Scottish domestic EPC data is available to download from Q4 2012 to Q2 2021 from Statistics Scotland [65]. Since EPC data for Northern Ireland is not currently available for bulk download, the study is restricted to mainland Great Britain rather than the whole of the United Kingdom.

The EPC not only provides information on the energy performance of the property but also details the house type and tenure and provides the reason for the EPC application, listing ECO, FiT, RHI and Green Deal as options. The Green Homes Grant did not have a stipulation that the home had to have a low EPC certification to qualify. Therefore, it is not possible to extract the EPCs for homes who applied for a Green Homes Grant, so these are excluded from the analysis. In addition, the scheme was restricted to England, only ran for 7 months and only benefited 47,500 homes of the 600,000 anticipated [71].

Since the EPC datasets are available at full postal address-level granularity it is possible to combine this data with other geographically linked information such as average neighbourhood income level, census area ethnicity counts to build a rich picture of the type of households that engage with domestic energy incentives and the type of households that do not (see Table 2 for a list of datasets). From the UK Census 2011 [66,67] we take household tenure, dwelling type and counts of people by ethnicity. We also use the Output Area Classification

Table 2
Datasets used in analysis.

Dataset	Geography	Year(s) available	Notes
Energy Performance Certificates [64,65]	Available at address level for E, W & S	2008–2022 (E & W) 2012–2021 (S)	Type of domestic energy incentive application (ECO, FiT, RHI & Green Deal) EPC Grade House type House tenure
UK Census [66,67]	Available at Output Area for E, W & S	2011	Counts of households by tenure Counts of households by dwelling type Counts of people by ethnicity Output Area Classification
2019 Indices of Multiple Deprivation [68,69]	Available at Lower Layer Super Output Area for E, W & S	2019	Income domain – rank of LSOA by income grouped into quintiles
Postcode to OA lookup file [70]	UK	2020	Database which maps every UK postcode to a census OA

[5] For most DEI schemes an EPC must have been issued within 24 months and in many cases a Domestic Energy Assessor triggers an EPC as the first step in the application process

[6] Less than ten years old

[7] At time of writing

(OAC). The OAC is a publicly available geodemographic classification generated from the 2011 census.[8] The OAC clusters Output Areas (OAs), the smallest census area geography, into one of 26 groups according to socio-demographic similarities [72]. We also take the income domain data from the 2019 Indices of Multiple Deprivation [68,69] to find out which income quintile the houses applying for incentives fall into. It is possible to link the address-level data from the EPC to the census collection data districts using look up tables [70] which map data on different areal units together.

3.2. Methodological approach

3.2.1. Data processing and aligning

The full GB EPC database contains over 22 million records between 2008 and 2022. The data from England and Wales contains every EPC issued so a household that has had several EPC certificates issued would appear several times. The Scottish data only provides the most recent certificate for a house. We are interested in the EPCs belonging to households who applied for a DEI. We load the full set of data into a Python database and extract the EPCs where the 'transaction type' variable is listed as 'ECO assessment', 'RHI application', 'FiT application' or 'assessment for green deal'. Alongside the information on the DEI applied for we also extract the dwelling type and tenure of the property, its EPC grade and its location. The IMD income domain data is processed to classify every Lower Layer Super Output Area into quintiles, where 1 represents the lowest income level and 5 the highest. Using the postcode to OA and LSOA lookup table, income quintile levels are mapped onto the EPC datasets. Similarly, we map the census data on to the EPC dataset.

3.2.2. Systematic testing of variables

Taking the variables of EPC grade, income quintile, tenure, dwelling type and location in turn we aim to determine whether households belonging to each subclassification (e.g. each EPC grade, each dwelling type) appear in our list of DEI households more or less likely than in the whole list of households for GB. Taking owner occupiers and ECO as an example, we calculate proportion of households in the whole of GB which are owner occupiers from the 2011 census, and the proportion of households who applied for ECO who are owner occupiers from the EPC database.

Then

$$\mathrm{P} = \frac{\mathrm{p}_{\mathrm{sample}}}{\mathrm{p}_{\mathrm{pop}}} \times 1000$$

where:

P Propensity of owner occupiers to apply for ECO
p_{sample} Proportion of ECO applications who are owner occupiers
p_{pop} Proportion of owner occupier households in GB

If P is equal to 1, then the application rate is the same regardless of tenure and if P is 1.5, say, this suggests applications rates 50 % higher than expected. Reporting propensities of households of that type who apply for incentives allows for easy comparison between the characteristics and means that we can determine which household characteristics are most important in explaining who applies for incentives. In addition, we use a Chi-squared test determine if there is a statistically significant difference between the observed distribution of applications and the expected distribution.

3.2.3. Developing a typology

After systematically testing individual household characteristics, we assess the usefulness of a household typology for determining who applies for DEIs. The Output Area Classification is an existing, freely available neighbourhood typology designed to classify UK Census Output Areas into one of 26 geodemographic types. We will explore whether the OAC can predict a household's likelihood to apply for a DEI or whether a new typology, constructed for this project, is more suited to this task.

3.2.4. Limitations

One of the stipulations for starting a Domestic Energy Incentive Application is having an up-to-date (typically <24 months old) EPC. While many households request an EPC as part of their DEI journey, many will already have an in-date certificate due to a house move or a previous DEI application. We are aware that is a substantial portion of missing certificates in our dataset of EPCs and we do not have the entire set of applications. Government figures are available for the number of installations but this is a different measure to the number of households who apply for a DEI: many of the figures quoted, state the number of measures, rather than the number of households and it is possible that a household may undertake many measures (Table 3).

Despite these issues, we *can* answer the question 'who applies for DEI' because we are interested in the type of applicants rather than who was successful, and we have a very large sample of household types to analyse. We can assess if the applicants are representative of the UK population as a whole or if there are certain common characteristics of households applying for DEI. However, we are making an assumption that the data we have is representative of the total number of households who apply.

Another issue with our dataset is that only the most recent Scottish EPCs are made available, so we miss any applications to schemes from houses that request a new EPC, perhaps due to a house sale. Again we must assume that the data we do have is representative.

4. Results

4.1. Systematic testing of variables

We first calculate the observed distributions of applications for ECO, FiT, RHI and the Green Deal, by energy efficiency grade, income, dwelling type and tenure from the EPC database.[9] We then compare these observed distributions with the expected distributions of energy efficiency grade, income, dwelling type and tenure taken from the entire EPC database and the 2011 UK census. These four different characteristic types are starting to reveal the propensity of a household to apply for incentives. Chi-squared tests reveal statistically significant differences between the observed and expected distributions for EPC Grade,

Table 3
Comparing the EPC database with official UK Government statistics on DEI installations.

Domestic Energy Incentive	Number of measures applied / homes according to Government Statistics (2013-end 2021)	Number of records in EPC database (2008-end 2021)
ECO assessment	3.3 million measures in 2.3 million properties	769,579
FiT applications	900,000 installations	308,974
RHI applications	14,000 measures installed	62,260
Green Deal	98,375 installations 47,500 homes	608,892 (assessed for GD) 38,556 (following GD)

[8] A new 2021 classification based on the 2021 Census will not be available until 2024

[9] Expected distributions taken from UK Census (dwelling type and tenure), UK Indices of Multiple Deprivation (income quintile) and entire EPC database removing older duplicate certificates (EPC Grade). Distributions provided in Supporting information data tables

Income, Dwelling type and Tenure for each incentive.

Table 4, shows the results for our systematic tests of which household characteristics lead to greater or fewer applications for Domestic Energy Incentives. The table reveals the propensity, how many times more likely, each household grouping is to apply for an incentive than expected.

In GB, three fifths of homes have an EPC graded D to G (the worst performing homes) and just 0.2 % of homes are rated A. If there was no significant difference between the energy performance of the home and the household's decision to apply for a domestic energy incentive, we would expect propensity to apply to be equal to 1 across the EPC scores and the chi-square test to show no statistical difference in the distribution of application. However, a statistically significant difference is found in distributions and Fig. 1 shows that 87 % of applications for both ECO and the Green Deal are from D to G rated homes and homes rated E to G are twice as likely to apply for ECO. The rate of applications from homes rated A applying for FiT is six times more likely than expected and Renewable Heat Incentives (RHI) applications from both A and G rated homes appear three times more than expected (see Table 4). For ECO and the Green Deal, we can assert that there is a strong rational signal at play in the applications for these incentives (people applying for support to improve the efficiency of their homes); but energy performance is unlikely to be the only driving factor.

Table 4 also reveals statistically significant differing application rates by income quintile. Homes in the lowest income quintile have an ECO application rate almost twice the expected rate. We find a similar high application rate from the lowest quintile for the Green Deal. This suggests that these policies have been reasonably successful in targeting the least wealthy homes. In contrast, households applying for FiTs are split evenly by income with a similar rate for each band. Note this contradicts earlier research which suggested that these incentives were more likely to be beneficial for wealthier socio-economic groups [1]. For RHI applications, the wealthiest households tend to disproportionately apply, which is what we would expect given the design of the scheme.

Table 4

Propensity of homes to apply for domestic energy incentives by household characteristic. Figures in bold red are over twice the average application rate, ** indicates statistically significantly different distribution to expected using chi-squared statistic $p < 0.01$. See SI tables for full calculations.

		Propensity to apply for incentives			
		ECO assessment	FiT application	RHI application	Assessment for green deal
EPC Grade**	A	0.19	**6.36**	3.31	0.32
	B	0.04	1.20	0.48	0.06
	C	0.44	1.13	0.83	0.38
	D	1.01	1.17	0.97	1.23
	E	**2.41**	0.23	1.20	**2.01**
	F	**2.68**	0.36	**2.96**	**2.49**
	G	**3.16**	0.30	**3.83**	**2.74**
Income Quintile**	1 – lowest	1.86	0.96	0.51	1.56
	2	1.07	0.87	0.52	1.02
	3	0.82	0.98	1.08	0.87
	4	0.67	1.15	1.59	0.81
	5 - highest	0.55	1.04	1.34	0.72
Dwelling type**	Detached & semi-detached	0.77	1.13	1.12	0.87
	Terrace	**2.36**	1.66	1.67	**2.11**
	Flat	0.12	0.02	0.04	0.14
Tenure**	Owned & shared ownership	0.91	1.32	1.09	1.16
	Private rented	0.98	0.11	0.19	0.85
	Social rented	1.35	0.73	1.48	0.57

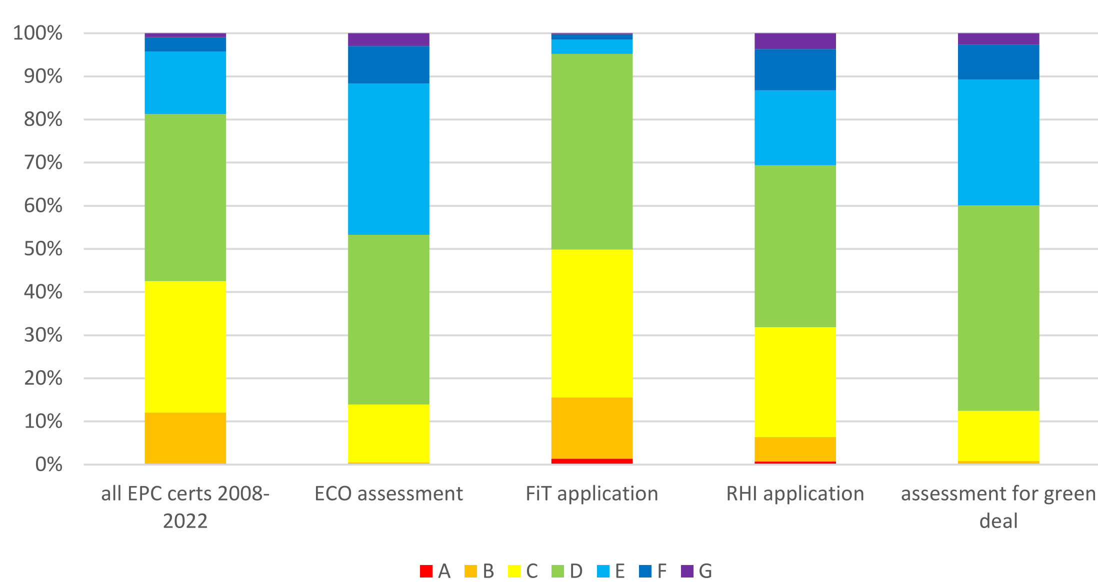

Fig. 1. Percentage of households by EPC Energy grade, and scheme type.

In the UK, 53 % of homes are detached or semi-detached, 24 % are terraces and the remainder are flats. Flats are under-represented in applications for domestic energy incentives, suggesting that this type of dwelling is less suitable for the retrofit options offered. Terraces are overrepresented in applications, particularly for ECO and Green deal. There are 2.36 and 2.21 times more applications respectively from terrace homes compared to the proportion of the UK housing stock that they represent. The presence of terraced housing in particular parts of England is linked to the legacy of the industrial revolution, during which this household type grew very rapidly to house the new industrial workers. Many neighbourhoods in industrial cities in the North of England and the Midlands are still dominated by this housing construction type, built at the turn of the 19th century. Terraced houses are often difficult to treat, having a solid wall construction and sometimes an aesthetic value, being built with local stone.

In the UK, 64 % of homes are owner occupied, 18 % are privately rented and the remaining 18 % are socially rented. Table 4 shows that there is a little difference in the rates of applications to the ECO scheme by household tenure, with slightly more applications from socially rented households and slightly fewer from owner occupiers, and this difference is statistically significant at $p < 0.01$. The Green Deal is similar but in this case, owner-occupier portions are slightly higher and the rental sectors lower. Homes classified as being privately rented have fewer applications for FiT and RHI. Owner-occupiers are over-represented in the applications for FiT and social renters over-represented in applications for RHI.

Next we determine whether there is a geographical clustering effect. Do we find the same pattern of applications everywhere in the country or are households in certain Local Authority areas more likely to apply?

Fig. 2 shows that there is a spatial distribution to applications for domestic energy incentives, with ECO and GD found in greater proportions in urban (non-London) local authorities and FiT and RHI in

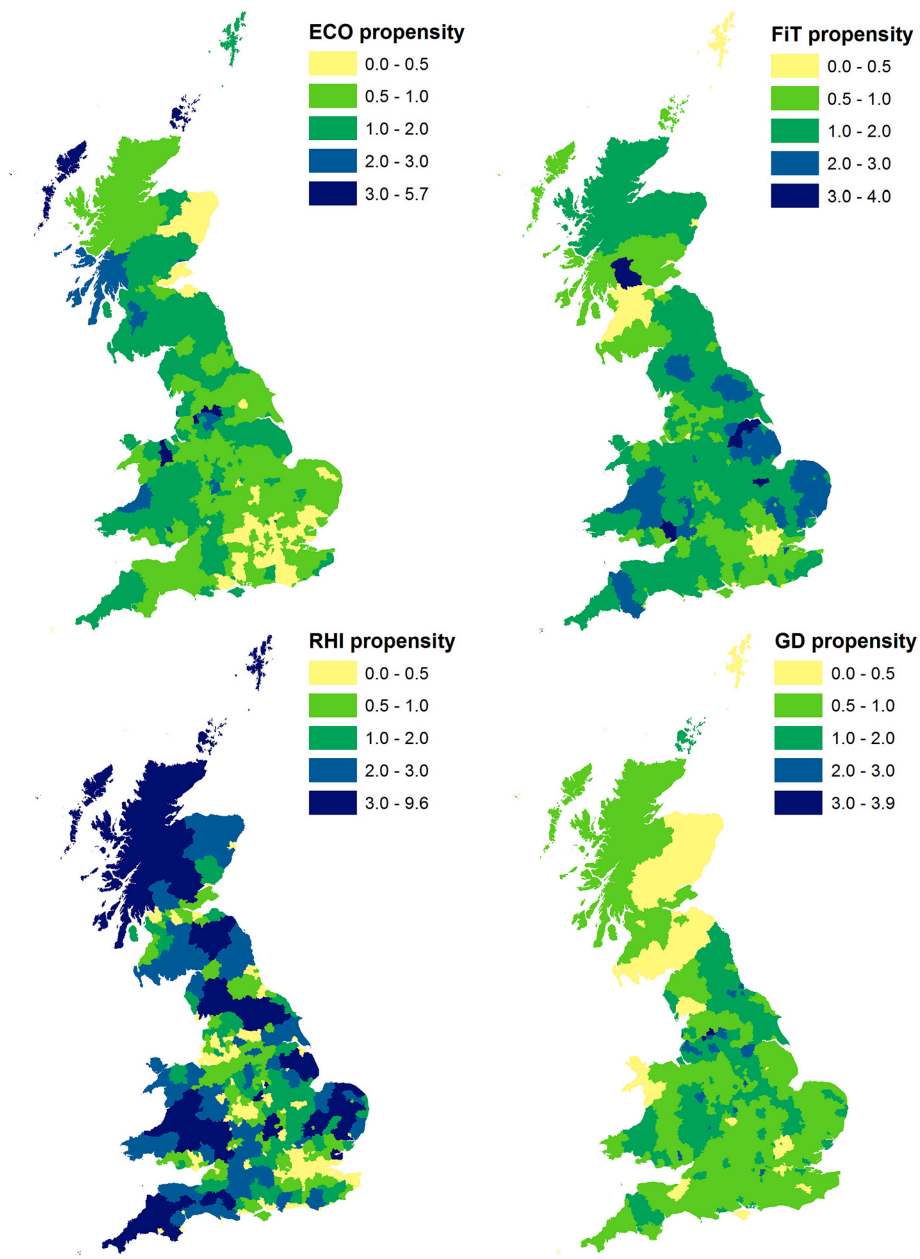

Fig. 2. Likelihood of households in Local Authorities to apply for domestic energy incentives. Likelihood is measured as a multiple of how many times more likely than the average with red showing the highest levels of applications. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

rural parts of the country. Focussing on the highest propensities, households in Bradford are 5.6 times more likely than the average household to apply for ECO. For FiT, Peterborough scores 3.9, Orkney scores 9.5 for RHI and Pendle 3.9 for GD. Are households in certain areas of the country more likely to apply for DEI because these areas are lower income and have higher numbers of owned inefficient houses or do we see applications at greater rates than expected taking these characteristics into account? In the following sections we aim to find this out.

4.2. The use of neighbourhood typologies

Given that our aim is to produce a typology which shows the different types of households who apply for DEIs we also evaluate the use of an existing neighbourhood typology: the Output Area Classification. We categorise each EPC datapoint into one of the 26 geodemographic types from the OAC. We aim to determine whether using a typology, which takes account of multiple household characteristics, can better describe the types of households applying for DEI than taking individual characteristics. Interestingly, when using a typology, we find higher application rates for ECO, RHI and the Green Deal than found in Table 2, meaning that this method of grouping households performs better at identifying those likely to apply for an incentive. However, EPC grade remains the best predictor of FiT application rate.

The groups with a higher likelihood of applying for FiT are 1a Farming Communities, 1b Rural Tenants and 1c Aging Rural Dwellers. These same 3 groups are much more likely to apply for the Renewable Heat Incentive, with 1a Farming Communities applying 6 times more than expected. Group 4b Challenged Asian terraces are nearly 3 times more likely to apply for the Green Deal. Rural households being more likely to apply for the renewable heat incentive is not an unexpected finding and this pattern is documented in an early Impact Assessment of the scheme (DECC, 2012b). The group '4b Challenged Asian terraces' account for 782,810 of the homes in the UK (3 % of the total number of households) and the EPC application rate for this group is over four times more than expected. The finding that ethnicity may play a role in likelihood of applying for ECO and the Green Deal is unexpected. The incentives have not been designed to target specific ethnic groups and this warrants further investigation.

It is clear that there is something interesting in the numbers relating to less wealthy, Asian households, who are living in terraces applying for the ECO and Green Deal schemes. But we also know that households are more likely to apply for ECO and Green Deal domestic energy incentives if they live in houses rated D or worse in Energy Performance, which is typical for terraced housing. In addition, we know that these schemes are targeted towards low-income groups and that people living in terraced houses apply for these schemes in greater numbers than in other house types. Do we see more applications from this group because the homes they are living in are the worst performing; because this group is overrepresented in the lowest income decile; because the schemes are designed for the building type they are living in; or is there a strong relational signal as well?

The OAC does not have the categories to help us answer these questions. We have used an existing typology and found it insufficient to properly determine the as yet unexamined role of ethnicity in DEI applications. Our next step will be to construct our own typology. Based on the findings in Tables 4 and 5, we hypothesise that low-income, households living in energy inefficient, terraces apply for incentives at a rate higher than expected. We will construct a typology which will allow us to determine whether there is over representation of Asian households in low-income, energy inefficient, terraced homes. Then to test if there is a relational signal we need to investigate an equivalent 'Challenged White Terraces' group to see if this group is also overrepresented in applications. In the next section we focus exclusively on the role of ethnicity in applications for ECO, to further investigate our unexpected finding.

Table 5

Propensity of homes to apply for domestic energy incentives by OAC. Figures in bold red are over twice the average application rate. ** indicates statistically significantly different distribution to expected using Chi-squared statistic $p < 0.01$. See SI tables for full calculations.

		Propensity to apply for incentives			
		ECO assessment	FiT application	RHI application	Assessment for green deal
OAC Type**	1a Farming Communities	1.02	**2.41**	**6.37**	1.08
	1b Rural Tenants	0.90	1.79	**4.51**	0.94
	1c Ageing Rural Dwellers	0.82	1.87	**4.42**	0.92
	2a Students Around Campus	0.72	0.24	0.26	0.71
	2b Inner-City Students	0.28	0.01	0.03	0.13
	2c Comfortable Cosmopolitans	0.61	0.10	0.08	0.56
	2d Aspiring and Affluent	0.17	0.09	0.06	0.36
	3a Ethnic Family Life	0.97	0.24	0.22	0.88
	3b Endeavouring Ethnic Mix	0.46	0.03	0.01	0.43
	3c Ethnic Dynamics	1.65	0.17	0.65	0.88
	3d Aspirational Techies	0.34	0.11	0.09	0.52
	4a Rented Family Living	1.15	0.78	0.35	1.25
	4b Challenged Asian Terraces	**4.18**	0.62	0.20	**2.92**
	4c Asian Traits	0.93	0.58	0.17	0.97
	5a Urban Professionals & Families	0.73	0.65	0.29	0.85
	5b Ageing Urban Living	0.65	0.73	0.59	0.80
	6a Suburban Achievers	0.60	1.30	0.83	0.74
	6b Semi-Detached Suburbia	0.69	1.30	0.41	0.89
	7a Challenged Diversity	1.34	0.75	0.55	1.16
	7b Constrained Flat Dwellers	1.88	0.16	1.07	0.51
	7c White Communities	1.50	0.76	0.50	0.87
	7d Ageing City Dwellers	1.45	0.42	1.08	0.58
	8a Industrious Communities	1.03	1.49	0.89	1.23
	8b Challenged Terraced Workers	1.56	1.00	0.33	1.69
	8c Hard-Pressed Ageing Workers	1.05	1.28	1.20	0.98
	8d Migration and Churn	1.28	1.40	0.41	1.47

Table 6
Variable selection for typology.

Variable	Divisions	Notes
Energy efficiency	A-C	>50 % of properties are A-C rated
	D-G	>50 % of properties are D-G rated
Dwelling type	Flat	>50 % of homes are 'Flat, maisonette or apartment' from 2011 census
	Terrace	>50 % of homes are 'Whole house or bungalow: Terraced (including end-terrace) from 2011 census
	Detached & semi-detached	<50 % of homes are Flat and < 50 % of homes are Terrace
Tenure	Owned	>50 % of homes are 'Owned and shared ownership' from 2001 census
	Not owned	<50 % of homes are 'Owned and shared ownership'
Income	Lowest quintile	ECO is focussed on low-income households
	Not lowest quintile	

Table 7
Household types, their distribution in terms of applications, their distribution across GB and their ECO application propensity. Figures in bold red are over twice the average application rate. Results show statistically significantly different distribution to expected using Chi-squared statistic $p < 0.01$. See SI tables for full calculations.

	Typology	% of ECO applications	% of GB households	Propensity to apply for ECO
1	Efficient, detached, not owned, not poor	1.0	1.2	0.84
2	Efficient, detached, not owned, poor	1.6	1.5	1.10
3	Efficient, detached, owned, not poor	4.4	7.0	0.63
4	Efficient, detached, owned, poor	0.6	0.6	1.07
5	Efficient, flat, not owned, not poor	3.0	5.2	0.59
6	Efficient, flat, not owned, poor	5.5	4.6	1.20
7	Efficient, flat, owned, not poor	1.5	2.4	0.63
8	Efficient, flat, owned, poor	0.4	0.3	1.44
9	Efficient, terrace, not owned, not poor	0.3	0.3	1.01
10	Efficient, terrace, not owned, poor	0.8	0.7	1.28
11	Efficient, terrace, owned, not poor	0.9	0.8	1.06
12	Efficient, terrace, owned, poor	0.4	0.2	1.62
13	Inefficient, detached, not owned, not poor	3.1	2.1	1.51
14	Inefficient, detached, not owned, poor	3.7	2.3	1.59
15	Inefficient, detached, owned, not poor	33.5	43.2	0.77
16	Inefficient, detached, owned, poor	4.7	2.9	1.62
17	Inefficient, flat, not owned, not poor	4.4	5.5	0.80
18	Inefficient, flat, not owned, poor	7.3	3.3	**2.22**
19	Inefficient, flat, owned, not poor	3.6	5.5	0.65
20	Inefficient, flat, owned, poor	1.9	0.8	**2.49**
21	Inefficient, terrace, not owned, not poor	0.9	0.7	1.35
22	Inefficient, terrace, not owned, poor	3.7	1.4	**2.74**
23	Inefficient, terrace, owned, not poor	5.6	5.9	0.96
24	Inefficient, terrace, owned, poor	7.0	1.8	**3.88**

4.3. Developing a typology: the role of ethnicity in applications for ECO

Here, we construct our own typology using census data, subdividing UK output areas by energy efficiency, dwelling type, tenure and income. We are moving from working with individual address point data from the EPC, where we know the exact efficiency, tenure and dwelling type of the house, to neighbourhood data which contain ~150 households. Output Areas cannot be classified as 'terraced', rather a count of the number of terraced properties is provided. We therefore make a set of assumptions to classify our neighbourhoods. We use a threshold to decide whether to classify a neighbourhood as 'terraced', 'flats' or 'detached and semi-detached'. The variables and thresholds are detailed in Table 6 below.

The two energy efficiency levels, three dwelling types, two tenure types and two income groups give a total of 24 possible OA typologies. Table 7 shows that the most prevalent type is type 15 which makes up 43.2 % of all GB OAs and 33.5 % of ECO applications. These are neighbourhoods dominated by energy-inefficient, owner-occupied, detached and semi-detached houses, which are not in the lowest income quintile. The rates of application by these households is slightly lower than average. But we are interested in those areas where the rate is unexpectedly high. Just 1.8 % of GB households are type 24 but they contribute 7.0 % of ECO applications. This is the type we hypothesised would be overrepresented in applications. These are neighbourhoods dominated by energy-inefficient, owner-occupied, terraced houses, which are in the lowest income quintile. As expected, this type has the highest rate of applications for ECO, almost four times the expected rate. Other household types with high applications for ECO are: a) energy inefficient flats that are not owner-occupied and in the lowest income quintile (type 18); b) energy inefficient flats that are owner-occupied and in the lowest income quintile (type 20) and; c)energy inefficient terraces that are not owner-occupied and in the lowest income quintile (type 22).

To understand the role of ethnicity in ECO applications we need to add ethnicity into our neighbourhood classification. Following Table 6 we produce the variable 'ethnicity' with the divisions 'white' where over 90 % of the population is white, 'Asian' where over 50 % of the population is Asian or British-Asian and 'Not all white' for the remaining OAs.

Just 2 % of GB neighbourhoods are classified as Asian, yet these neighbourhoods represent one sixth of group 24 (owner occupiers of low income living in energy inefficient terraces (see Table 8)). Households of Asian origin are overrepresented in the group most likely to apply for

Table 8
A focus on Group 24: investigating the effect of ethnicity of applications for the ECO incentive. Results show statistically significantly different distribution to expected using Chi-squared statistic $p < 0.01$. See SI tables for full calculations.

		% of group 24	% of applications for ECO in group 24	Propensity to apply for ECO within group 24	Propensity to apply for ECO across all GB
24a	Asian, Inefficient, terrace, owned, poor	16.5 %	51.2 %	3.11	11.86
24b	Not all white, Inefficient, terrace, owned, poor	28.6 %	21.5 %	0.75	2.87
24c	White Inefficient, terrace, owned, poor	55.0 %	27.4 %	0.50	1.90

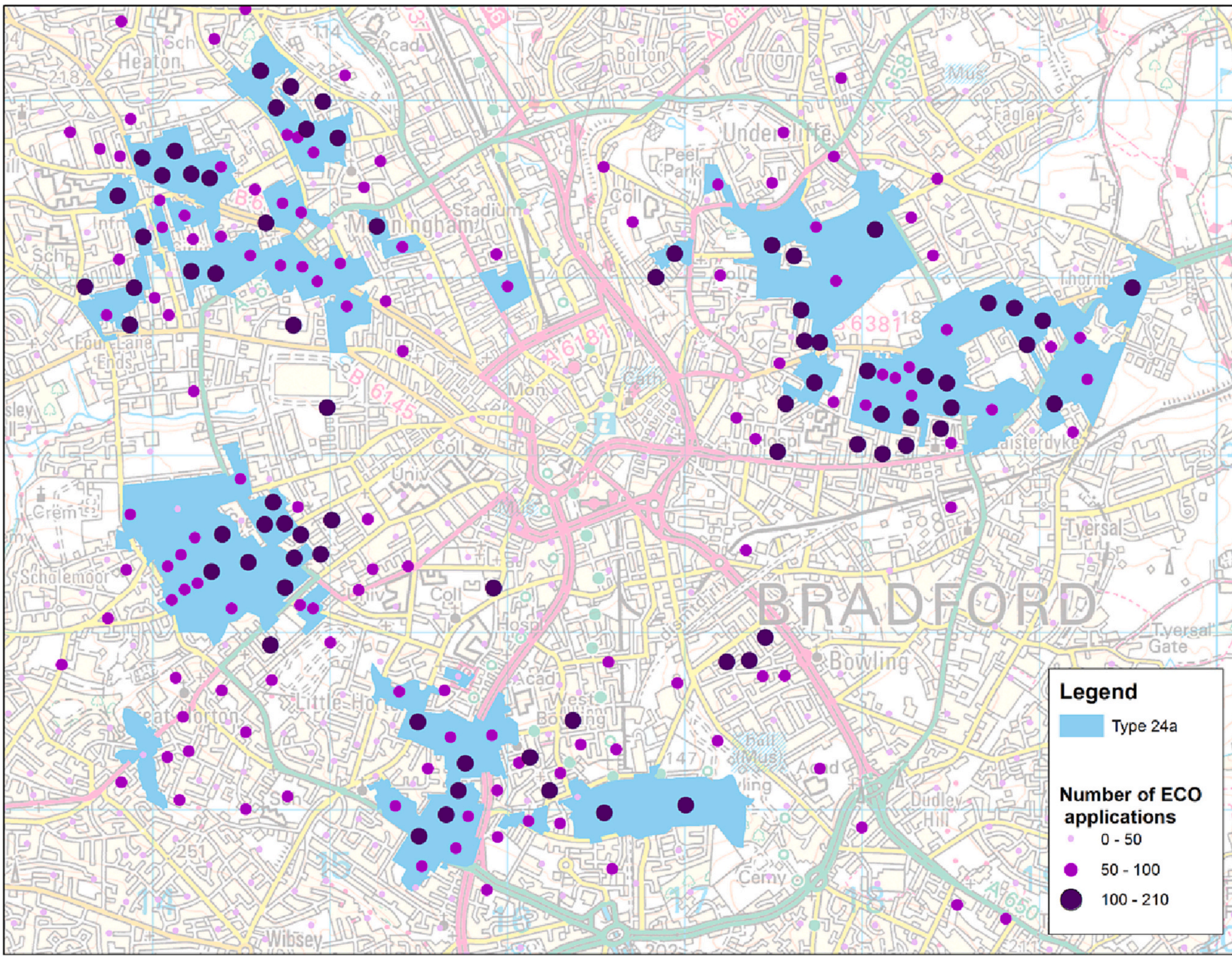

Fig. 3. Location of Type 24a classified OAs in the Bradford city area with numbers of ECO applications per OA overlaid.

domestic energy incentives. However, if we look at the number of applications by households of this type (see Table 8), households of Asian origin represent 51.2 % of applications (much higher than one sixth), applying at a rate that is three times higher than expected and twelve times higher than the average GB household's ECO application rate. Ethnicity has a statistically significant[10] role in the application rate of these household types.

4.4. Is there a community effect to applications for ECO in Bradford?

Fig. 2 considered geographical clustering in the rates of applications for DEIs and revealed the overrepresentation of applications for ECO in Bradford. Fig. 3 maps type 24a from the new typology on to the Output Areas in the city of Bradford and overlays the ECO application data. It is clear that the clusters of applications for ECO are concentrated in the parts of the city classified as type 24a. But are we seeing high rates of applications for ECO in Bradford due to the fact that households of type 24a are over-represented here or is the rate even stronger than expected?

There are 37 Local Authorities in the UK where households classified as ‘Asian origin owner occupier households of low income living in energy inefficient terraces’ (type 24a) applied for ECO incentives. If these types of households in every LA applied in the same proportions that we would expect for this type of household, we would see propensities of 11.86 (the average rate for type 24a country wide) for all Local Authorities. In Bradford, the propensity of households classified as type 24a to apply for ECO is 26.1. Low-income households of Asian origin, living in owned, energy inefficient terraces in Bradford are over

[10] Significant at $p < 0.01$ in Chi-Squared Test

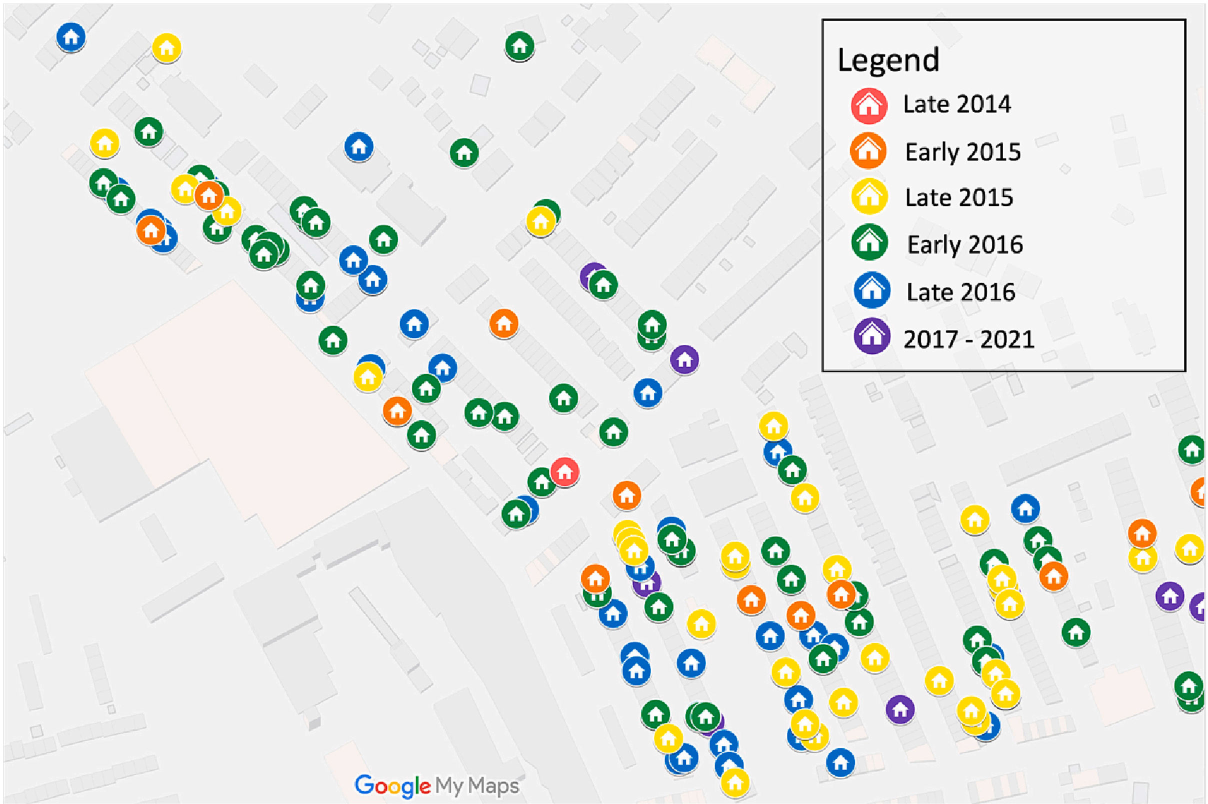

Fig. 4. ECO applications by Asian origin owner occupier households of low income living in energy inefficient terraces in a northwest area of Bradford by date (Google Maps).

26 times more likely to apply for ECO than expected. This is more double the expected rate of type 24a, suggesting geography has a statistically significant[11] role in the distribution of applications for ECO by type 24a households. Other Local Authorities with rates higher much higher than expected are Calderdale (18.4), Kirklees (15.0) and Leeds (14.1) – all found in the West Yorkshire region.

To attempt to test the idea of a community effect to the pattern of ECO applications by households of type 24a in Bradford, we again turn to the EPC database. Focussing on the area to the north west of Bradford (see Fig. 3), where applications to ECO are particularly dense, we sort the applications by date and plot on a street map (Fig. 4). It is possible to see the spread of applications radiating out along the streets. We observe that in this area of Bradford, ECO applications in the earlier years are concentrated in the south-east of the map and there are greater concentrations of applications in the latter years towards the north and west.

At this stage in our analysis we feel we have reached the limits as to what can be interpreted from quantitative spatial datasets. Evidence suggests that for certain household types in certain parts of the country, rates of application to ECO are greater than expected based on income levels and house types. This suggests a relational and perhaps community effect is in operation. To fully determine whether this is the case, we plan to build on the quantitative data we have investigated and venture into the field with a follow up project.

5. Discussion

5.1. Some tentative explanations for our unexpected findings

Our analysis of the quantitative data on who applies for energy incentives raises some interesting questions, most of which start with the word 'why'. While we have clearly shown that there is a higher propensity for certain social groups to apply for different incentives, it is more challenging for us to fully explain these patterns using secondary quantitative data. For instance, we do not currently have an answer to the questions: why do more people from Asian ethnicity living in terraced housing apply for grants than White people in similar housing? Why are there not more people from Asian ethnicity in terraced housing in the South of England applying for these grants? Was ECO advertised and promoted differently in West Yorkshire?

There are some regularities here that can be explained by the design of the policies. We can come up with an explanation as to why households on low incomes and living in terraced housing apply for ECO in greater numbers. The reason that the ECO scheme has higher uptake among such households, is likely to be because of its increasing focus on low-income households over time (see Table 1), and its accessibility for households looking to engage in relatively small retrofit measures that are appropriate for this housing type (e.g. boiler replacements). This does not explain why people with Asian ethnicity apply in such great numbers.

In addition, the geographical spread of these households which are located across multiple local authority jurisdictions, cannot be explained merely by a single active local government promoting national grants. If that were the case, we would expect to see a distribution of applications clustered by geography only, not by geography and household demographics. There are likely to be key actors in the spread of ECO to these households, which we cannot identify through our secondary quantitative data analysis. We are currently engaged in qualitative research in Bradford, as a result of which we hope to provide more answers to these questions: including finding out who are the key actors in spreading this policy, and understanding how this substantial propensity to apply for ECO came about.

While the specific reasons for the huge propensity of terraced

[11] Significant at $p < 0.01$ in Chi-Squared Test

homeowners on low-incomes and with Asian-ethnicity in Bradford to apply for energy grants (26.6 times more likely to apply) remain elusive, we can test the various explanations that we profiled in the part 2 above for their efficacy in explaining these patterns. Certainly, an explanation based on rational choice or financial motivations is insufficient: while these households may be motivated by saving money, they are also applying in much larger numbers versus similar households that might be assumed to have similar financial motivations. An assumption of rationality does not allow us to anticipate who will and will not apply, or how uptake of energy incentives spreads in the wider population.

We can see how a social relational explanation might begin to make sense in explaining our incidental findings on which households apply for domestic energy incentives. The fact that households from a specific ethnic minority and income group, living in homes of a particular construction type, in a part of England with a distinct social history, applied for these incentives in much greater number than elsewhere, suggests a highly relational pattern of policy spread. Ethnicity is likely to be shaping applications by a combination of identity (sense of belonging, and shared practices) and through specific affiliations between people (including intimate others) and organisations, rooted in a particular place, and engaging with other people in the community [44]. The fact that people living in terraced housing in the North of England are applying in such high numbers is also linked to the historical presence of these dwellings in ex-industrial heartlands. These are areas that experienced high levels of migration after the Second World War, due to large numbers of jobs, and relatively cheap housing. Our map of a possible community effect (Fig. 4) suggests a role for family and friends, and local institutions in the public, private and third sector in spreading enthusiasm and engagement with a policy.

Our findings challenge conceptualisations of people from ethnic minorities as 'hard to reach', 'unable to access information', or passive subjects of environmental harm. In these terraced households in the north of England, in the years 2008–2021, Asian-ethnicity households were taking the initiative and applying for ECO in huge numbers. The uptake of these incentives seems to have spread through neighbourhoods as people applied for incentives, and, possibly, recommended incentives to family, friends and neighbours. These Asian households may have been responding rationally to incentives, but our evidence suggests that their ethnicity, just as their belonging to a particular ethnic minority, and their social ties with others with that ethnicity, was part of what shaped this response.

5.2. What does this mean for policy/practice?

Energy policy that operates on a first-come first-served basis, remains intentionally blind to racial and gender inequalities. Class, however, is factored into the equation for recent iterations of ECO with its focus on low-income homes. Other energy policies such as FiT and RHI could have negative distributional justice outcomes, but arguably were put in place to accelerate a technological transition by leveraging middle class capital and were successful at doing so, particularly in the case of the FiT. Our work here, shows that it is not always that case that ethnic minority groups are disadvantaged by first-come first-served energy policy. In contrast to most scholarship on energy and ethnicity to date, we find an active and engaged segment of the population adopting energy retrofit measures in 'Challenged Asian Terraces' in great numbers in West Yorkshire.

Using a relational explanation allows us to speak about policy adoption beyond the atomised 'rational household perspective'. It allows us to hypothesise not only network effects, but to suggest where those networks might end and why. Where relations of ethnic identity and community cease, our enthusiastic take up of ECO also ceases. It did not spread to 'challenged white terraces', for example, which we might expect given the similarity in housing type and energy inefficiencies.

The implication for energy policy is substantial. First, that a 'first come-first served' capital subsidy does not always disproportionately benefit affluent white homes, nor does it incentivise the most 'rational' application of public subsidy. Instead, some groups will benefit more than others, largely based on as yet unknown mechanisms of relational uptake. Second, while we do not yet know the specifics of this case and look forward to upcoming qualitative insight from our follow-on project, we now know that the social networks and relations surrounding energy policy very likely play a role in its success and uptake. This has significant ramifications for the way in which energy policy is designed, implemented and made visible within and across a far broader mix of communities across the UK, and by implication, globally. Energy policy that seeks to meet global decarbonisation targets within remaining timeframes would do well to factor in relational, as well as rational, dynamics.

6. Conclusion

We set out to explore who applies for domestic energy policies in Great Britain. Our initial assumptions were that, while energy policy is aimed at rational individuals, those with high social capital (broadly the 'middle class') would be over-represented and be benefitting disproportionately from state subsidy. While this demographic is more heavily represented in applications to the policies that require up-front investment (FIT, RHI), those that aim to serve lower income households are succeeding in doing that. However, one group is substantially over-represented in the data. Households from neighbourhoods with large Asian populations, dominated by energy-inefficient, owner-occupied, terraced houses, which are in the lowest income quintile were 12 times more likely than average to apply for some domestic energy policies. We have offered a relational explanation for this, which takes accounts of peoples' relations with others including intimate relations, institutions, location in place and identity. We argue that the implications for policy are that attention to fostering relational networks could be beneficial to drive uptake. In this work it seems that ethnicity acts as a positive relational driver of uptake as opposed to a market of 'hard to reach' groups. We intend to explore the qualitative mechanics of these relations in the communities identified as part of our further work on social relations in energy policy.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Anne Owen, Lucie Middlemiss, Donal Brown, Mark Davis, Stephen Hall, Ruth Bookbinder, Marie Claire Brisbois, Iain Cairns, Matthew Hannon and Giulia Mininni report financial support was provided by UK Energy Research Centre.

Data availability

Two supporting information items available
Supporting information document (Original data) (Dataverse)
Supporting information document (Original data) (Dataverse)

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