Applied Energy 226 (2018) 353–364

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis

Philippa Roddis[a,*], Stephen Carver[a], Martin Dallimer[b], Paul Norman[a], Guy Ziv[a]

[a] University of Leeds, School of Geography, Garstang Building, LS2 9JT, United Kingdom
[b] University of Leeds, School of Earth and Environment, LS2 9JT, United Kingdom

HIGHLIGHTS

- Analysis of planning outcomes for onshore wind and solar farms in Great Britain.
- Indicators for community acceptance are tested using binomial logistic regression.
- 12 acceptance variables found to be significantly correlated with planning outcomes.
- Material arguments found to be more influential than attitudinal/social influences.
- Implications for public acceptance, policymaking and energy justice are discussed.

ARTICLE INFO

Keywords:
Renewable energy
Public acceptance
Community acceptance
Energy justice
Onshore wind
Solar farms

ABSTRACT

The deployment of renewable technologies as part of climate mitigation strategies have provoked a range of responses from various actors, bringing public acceptance to the forefront of energy debates. A key example is the reaction of communities when renewable projects are proposed in their local areas. This paper analyses the effect that community acceptance has had on planning applications for onshore wind and solar farms in Great Britain between 1990 and 2017. It does this by compiling a set of indicators for community acceptance and testing their association with planning outcomes using binomial logistic regression. It identifies 12 variables with statistically significant effects: 4 for onshore wind, 4 for solar farms, and 4 spanning both. For both technologies, the visibility of a project, its installed capacity, the social deprivation of the area, and the year of the application are significant. The paper draws conclusions from these results for community acceptance and energy justice, and discusses the implications for energy decision-making.

1. Introduction

The deployment of renewable energy technologies as part of the transition to a low carbon economy has provoked a broad range of responses from a variety of actors, bringing issues of 'public acceptance' to the forefront of energy debates [1–3]. In some cases, the views of the public have (at least ostensibly) informed energy decision-making such as the phase out of nuclear power generation in Germany, partly motivated by public concerns over safety following the Fukushima disaster [4], and the phase out of onshore wind subsidies in the UK on which the government stated: "we are reaching the limits of what is affordable, and what the public is prepared to accept" [5]. In other cases, energy policies and projects have proceeded despite strong negative public reactions, such as large-scale hydropower projects in environmentally sensitive areas of Brazil and China [6], fracking for shale gas in the UK [7], and controversial coal mining projects in Australia [8]. This raises empirical and ethical questions about the role(s) that public acceptance can, does and should play in formulating energy policy and informing energy deployment. It also leads to theoretical questions around the relationship between public acceptance and the concept of energy justice, which have received limited attention in the existing literature in this area.

As a relatively novel theoretical approach, the conceptualisation of energy justice is still taking shape. McCauley et al. [9] describe energy justice as having a 'triumvirate of tenets': distributional, procedural and recognition justice. The distributional aspect draws upon environmental justice theory, which originates from research conducted in the USA in the 1970s and 80s revealing that low environmental quality and

* Corresponding author.
E-mail addresses: P.Roddis1@leeds.ac.uk (P. Roddis), S.J.Carver@leeds.ac.uk (S. Carver), M.Dallimer@leeds.ac.uk (M. Dallimer), P.D.Norman@leeds.ac.uk (P. Norman), G.Ziv@leeds.ac.uk (G. Ziv).

https://doi.org/10.1016/j.apenergy.2018.05.087
Received 15 October 2017; Received in revised form 3 May 2018; Accepted 22 May 2018
Available online 06 June 2018
0306-2619/ © 2018 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/BY/4.0/).

high environmental hazards were frequently concentrated in minority and economically disadvantaged communities [10–11]. Similar patterns have since been identified in many other countries such as Mexico, France and the UK [12–14], showing that poorer communities tend to bear the burden of environmental ills such as air pollution, water pollution, and exposure to hazardous wastes. In relation to energy, distributional injustices have been identified in many forms including energy poverty [15–16], the labour market [17], and infrastructure siting such as fracking and nuclear power development [18–19]. However, despite some recent academic attention (e.g. [20]) the distributive elements of renewable energy development have been relatively overlooked, perhaps because it is often regarded uncritically as an environmental and social good.

Procedural justice refers to equitable participation in decision-making for all affected stakeholders in a non-discriminatory way [21]. It demands appropriate and sympathetic engagement mechanisms [22] and for the views of all stakeholders to be taken seriously throughout the decision-making process [9]. It also requires impartiality and full information disclosure by those in positions of authority, such as government and industry [23]. In relation to energy decision-making, this includes processes such as public consultation on infrastructure siting decisions, and transparency relating to information such as public subsidies for different energy sources [24]. This tenet of energy justice has received greater attention in relation to renewable energy than distributional justice, particularly relating to wind power siting decisions (e.g. [25–28]). Recognition justice, whilst similar to procedural justice, is differentiated by its focus on *fair* representation, recognising that some groups are at a disadvantage within formal participation processes [29]. A lack of recognition could manifest itself in "various forms of cultural and political domination, insults, degradation and devaluation", as well as "a failure to recognise" or "misrecognising" i.e. a distortion of people's views that does not reflect their true position [9]. Within the field of energy, recognition justice draws attention to the dominance of certain demographics within energy decision-making processes, and the need to recognise and integrate the perspectives of less powerful stakeholders.

In this paper, we consider the implications for these tenets of energy justice (particularly distribution) of onshore wind and solar farm deployment in Great Britain (GB). These are the two most commonly deployed land-based renewable technologies in the country [30], having experienced major growth in recent years. We investigate the role that community (i.e. local) acceptance has played in planning outcomes for these technologies through statistical analysis of variables which correlate with successful and unsuccessful planning outcomes. All applications made between 1990 and 2017 are analysed (as far back as data are available). Whilst some existing studies consider similar issues in relation to a case study area or individual development (e.g. [31–32] the approach of this paper is novel in that it uses geospatial datasets to analyse planning outcomes across the whole of GB over an extended time period. In Section 2, we present a conceptual framework Fig. 1) for understanding the variables which influence community acceptance of onshore wind and solar farms, based on a detailed literature review. The methods for the statistical analysis are outlined in Section 3, and results are presented in Section 4. Section 5 then discusses these empirical results and considers the relationship between public acceptance and energy justice: a theoretical gap in the existing literature on the topic. Section 6 provides key conclusions and recommendations for future research.

2. Theory

'Public acceptance' can be divided into three dimensions [33]: *socio-political* (acceptance by policymakers and the general public, typically gauged through opinion polls which provide an aggregated representation of attitudes); *market* (acceptance of new technologies by adopters such as households and businesses, or as indicated through willingness-to-pay models); and *community* (acceptance by local communities affected by the implementation of a technology, for example siting decisions for renewable energy). In this paper, we focus on community acceptance i.e. the reaction of citizens when an onshore wind or solar farm project is proposed in their local area. Fig. 1 synthesises insights from the public acceptance and environmental planning literature on the variables which are expected to influence community acceptance of onshore wind and solar farms. Variables can be categorised as 'material arguments' used to oppose and/or support projects, or 'attitudinal/social influences' i.e. factors which influence positive/negative social responses to these technologies.

Material arguments against onshore wind and solar farms are commonly based around visual impacts on scenic areas and 'wild' landscapes [34–36]. The type of land cover can also influence acceptance of these technologies [37–38]. Other material arguments focus on environmental impacts and ecosystem services, such as bird collision with wind turbines, given the implications for biodiversity conservation [39]. Economic concerns are another category of material argument in support of and/or opposition to these technologies, such as impacts on property prices, tourism, employment, and agricultural production [17,40–42]. Finally, project details also contribute to material reasons for support or opposition, including the size of the project [43], irritations such as noise and shadow flicker in the case of onshore wind [44] and glare in the case of solar farms [45], as well as project ownership structures i.e. whether the project is owned and managed by a private company, individual or community group [46].

As well as material arguments, community acceptance can be affected by the attitudes and characteristics of local residents [47–48]. For example, demographic attributes can influence views towards renewable energy, particularly age, with older people tending to be less accepting that younger people [49–50]. Demographic variables such as social deprivation can also influence the extent to which residents take action on renewable energy projects proposed in their local area; communities with higher social capital are more likely to engage in official planning processes due to their higher capacity, agency and access to networks [51–52]. Political values and beliefs have also been found to influence attitudes towards and acceptance of renewable energy developments [53], as well as temporal factors, with people tending to become more accepting as a result of exposure over time [54–55]. These types of variables can be expected to have an effect on which type(s) of people support/object to onshore wind and solar farm projects, and (in turn) the geographical distribution of support for and opposition to these technologies e.g. by country/region.

These 'acceptance variables' feed into decision-making in different ways in different contexts. Details of how this process operates in this paper's case study of GB follows in Section 3. We acknowledge that the material arguments outlined in this section may also be fed into decision-making through channels other than local citizens; NGOs, pressure groups or statutory agencies may also raise concerns around biodiversity or visual impacts, for example. We discuss the implications of this potential collinearity between influences on decision-making in our discussion in Section 5. It should also be acknowledged that there is more research on community acceptance of onshore wind than solar farms, meaning that higher confidence can be placed in the acceptance variables identified for onshore wind.

3. Material and methods

3.1. Case study

GB (comprising England, Scotland and Wales) was selected as a case study due to the broadly similar policy drivers and planning legislation for renewable energy over this time period, as well as comparable data availability. Since the early 1990 s, the configuration of the electricity supply system in GB has shifted from centralised conventional power stations and remote hydropower stations to increasingly visible

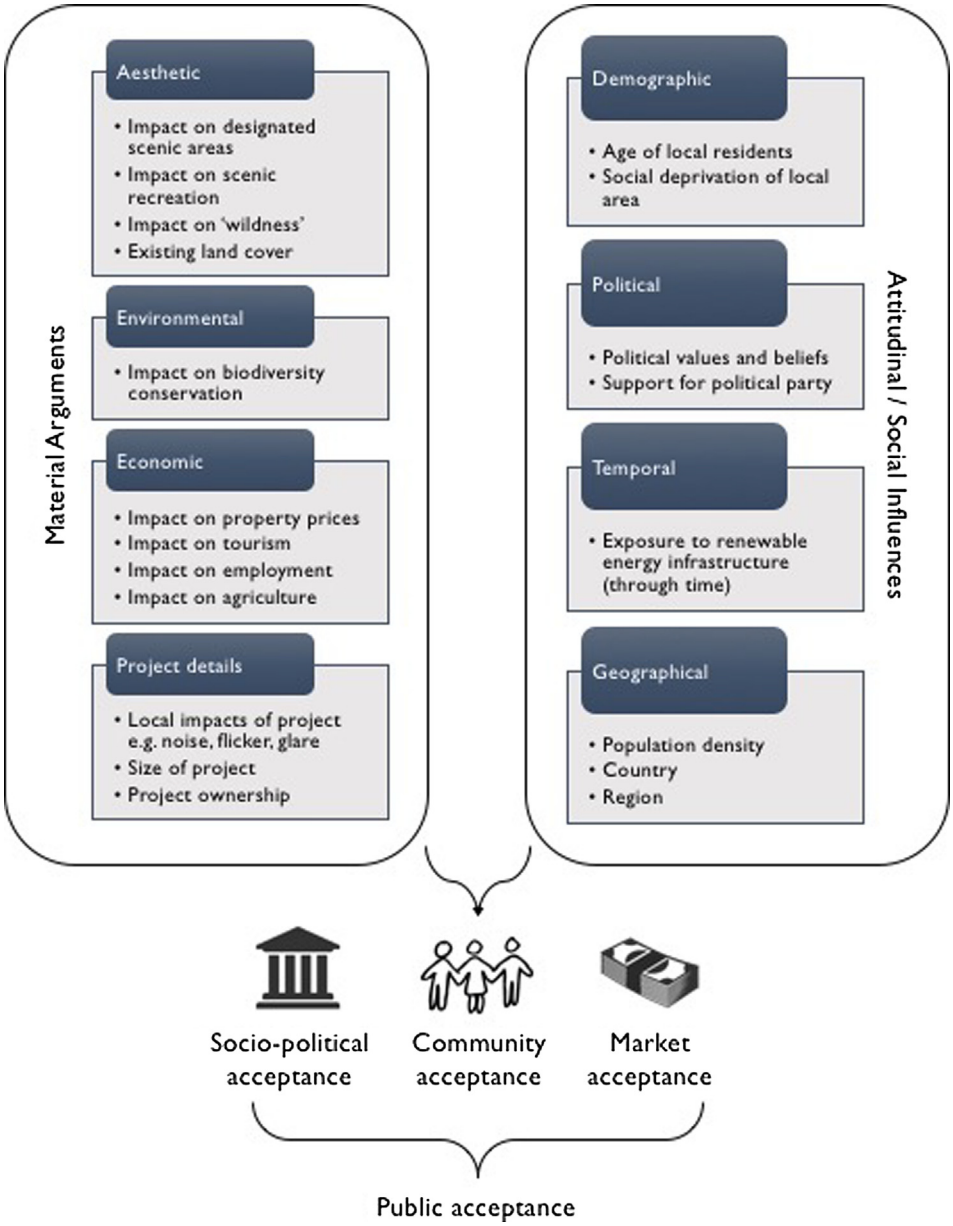

Fig. 1. Framework of 'acceptance variables' contributing to community acceptance of onshore wind and solar farms based on authors' literature review, building on 'the triangle of social acceptance of renewable energy innovation' [33].

decentralised renewable energy sources such as onshore wind and solar farms. Whilst receiving high general public approval ratings of between 64 and 73% (onshore wind) and 80–87% (solar) in the UK Government's Public Attitudes Tracker since the survey began in 2012 [56], the deployment of these technologies has frequently been marked by public opposition at the local level [27,57]. In this paper, we investigate for the first time in a single analysis whether variables relating to community acceptance are statistically associated with planning outcomes for onshore wind and solar farms. We hypothesise that community acceptance has played a role in planning outcomes via the public participation mechanism outlined in the following paragraph. Our results have implications for procedural and recognition justice in terms of whose opinions are heard in decision-making processes; they also have implications for distributional justice in terms of where onshore wind and solar farm projects are ultimately sited, and consequently who (and where) is exposed to the positive and negative impacts of renewable energy developments.

In GB's planning system(s), the public are given the opportunity to provide their views on planning applications to the Local Planning Authority (LPA). The period of consultation usually lasts for 21 days, and the LPA will identify and consult a number of different groups [58]. These include public consultation, statutory consultees, non-statutory consultees and any specific consultation required by a direction. As well as residents of the local area who might be directly affected by the application, other individuals, community groups and interest groups (both local and national) are also able to respond to consultations. Once the consultation period has concluded, the representations are considered by the LPA (either a Planning Officer, or a Planning Committee if the case is particularly complex or controversial) which makes the decision as to whether permission should be granted, granted with conditions, or refused (Planning [59]. It is through this process that citizens can highlight material arguments relating to specific projects (in support or opposition) to decision-makers. Attitudinal/social influences can be expected to have an influence on who (i.e. which types of citizen) engages in this process. If the decision is either refused, granted with conditions, or not made within the time period set by planning law

Table 1
'Acceptance variables' used to test the effect of community acceptance on planning outcomes for onshore wind and solar farms in Great Britain between 1990 and 2017.

Category of variable		Acceptance variable	Indicator used for variable	Unit of analysis	Data source(s)	Data year(s)	Used in wind model	Used in solar model
Material arguments	Aesthetic	Impact on scenic areas	Areas of Outstanding Natural Beauty (England and Wales), National Scenic Areas (Scotland)	Distance to feature (km)	Natural England (NE), Natural Resources Wales (NRW), Scottish Government (SG)	2011 (NRW, SG), 2017 (NE)	Y	Y
		Impact on scenic recreation	Distance to National Parks	Distance to feature (km)	NE, NRW, SG	2010 (NRW), 2011 (SG), 2016 (NE),	Y	Y
		Impact on 'wildness'	Naturalness*	Naturalness score (1–256), 50 × 50m cell	Authors' data	2016	Y	Y
			Ruggedness*	Ruggedness score (1–256), 50 × 50m cell	Authors' data	2016	Y	Y
			Remoteness*	Remoteness score (1–256), 50 × 50m cell	Authors' data	2016	Y	Y
			Visibility of modern artefacts and structures*	Visibility score (1–256), 50 × 50m cell	Authors' data	2016	Y	Y
		Existing land cover	Land cover category	Joint Nature Conservation Committee (JNCC) Broad Habitat Types, 25 × 25m cell	Centre for Ecology and Hydrology (CEH)	1990, 2000, 2007, 2015	Y	Y
	Environmental	Impact on biodiversity conservation	Sites of Special Scientific Interest (SSSIs)	Distance to feature (km)	NE, NRW, Scottish Natural Heritage (SNH)	2016 (SNH), 2017 (NE, NRW)	Y	Y
			Special Areas of Conservation (SACs)	Distance to feature (km)	NE, NRW, SNH	2016 (NRW, SNH), 2017 (NE)	Y	Y
			Special Protection Areas (SPAs)	Distance to feature (km)	NE, NRW, SNH	2010 (NRW) 2016 (NE, SNH)	Y	Y
			Ramsar sites (Wetlands of International Importance)	Distance to feature (km)	NE, NRW, SNH	2010 (NRW), 2012 (SNH), 2016 (NE)	Y	N**
			National Nature Reserves	Distance to feature (km)	NE, NRW, SNH	2016 (NE, NRW, SNH)	Y	Y
			Local Nature Reserves	Distance to feature (km)	NE, NRW, SNH	2016 (NE, NRW, SNH)	Y	Y
	Economic	Impact on agricultural production	Grade of agricultural land	Agricultural grade (1–6), 5x5km cell	James Hutton Institute (JHI), NE, Welsh Government (WG)	2011 (JHI), 2013 (NE), WG (2016)	Y	Y
		Impact on tourism	Tourist visits	Number of visits to county (staying 1 + night)	Visit Britain	2002 – 2016	Y	Y
		Impact on local employment	Employment in renewable energy sector	Number of jobs in region	Renewable Energy Association (REA)	2010 – 2015	Y	Y
	Project details	Project size	Installed capacity	Megawatt	REPD	2017	Y	Y
			Turbine capacity (wind only)	Megawatt	REPD	2017	Y	N**
		Project ownership structure	Name of operator or applicant in REPD	Private or community/individual ownership	REPD	2017	Y	Y
Attitudinal/social influences	Demographic	Age of residents	16–24 year olds	Percentage of total population in LAD	UK Census	1991, 2001, 2011	Y	Y
			65 + year olds	Percentage of total population in LAD	UK Census	1991, 2001, 2011	Y	Y
		Social deprivation	Townsend Index	Townsend Index score of LAD	Authors' data, calculated from the UK Census	1991, 2001, 2011	Y	Y
	Political	Local political values	Political party in control of Local Planning Authority (LPA)	Political party in control of LPA*** (Conservative, Labour, Lib Dem, Other)	BBC, Wikipedia	1990 – 2017	Y	Y

(*continued on next page*)

Table 1 (*continued*)

Category of variable		Acceptance variable	Indicator used for variable	Unit of analysis	Data source(s)	Data year(s)	Used in wind model	Used in solar model
	Temporal	Exposure to renewable energy infrastructure	Date of planning application	Year	REPD	2017	Y	Y
	Geographical	Geographical location	Country in GB	Country (England, Scotland, Wales)	REPD	2017	Y	Y
			Population density	Persons per hectare in LAD	UK Census	1991, 2001, 2011	Y	Y

NB. Other variables with theoretical value to this analysis include: impacts on property prices (e.g. indicated by rates of home ownership), impacts on species (indicated by species distribution rather than protected areas for biodiversity), and other sociodemographic variables such as gender. These were not included in the models presented in this paper for a range of reasons, including collinearity (e.g. home ownership is an indicator within the Townsend Index), lack of data availability (e.g. on species distribution), or lack of sufficient geographical variation in the data (e.g. gender).

* These indicators follow the methodology in Carver et al. [61] for mapping wildness: 'naturalness' refers to the perceived naturalness of land cover, 'ruggedness' refers to the nature of the terrain, 'remoteness' refers to the minimum access time from the nearest road, and 'visibility of modern artefacts and structures' refers to the lack of artificial structures or forms within the visible landscape.

** Ramsar sites (Wetlands of International Importance) were excluded from the solar model as diagnostic tests showed collinearity with one or more other independent variables in this model. Turbine capacity is not relevant to the solar farm model as this refers to the capacity of wind turbines, so is included in the wind model only.

*** Local Planning Authorities (LPAs) are the public authority whose duty it is to carry out planning functions for a particular area. This includes county councils, district councils, single-tier authorities (e.g. London Boroughs, unitary authorities, National Park authorities) and council areas in Scotland. The unit of analysis used for this indicator is therefore the political party in control of the LPA, which is the same as the political party in control of the relevant administrative entity listed above (i.e. the entity in which the wind/solar planning application falls). The exception to this is when an energy generating project is greater than 50 MW, in which case it is classed as a Nationally Significant Infrastructure Project and the planning decision is made by the Planning Inspectorate (in England/Wales) or the Scottish Government (in Scotland). In this analysis, these cases would be classified as 'other', as would any political party other than Conservative, Labour or Liberal Democrat.

Table 2
Categorisation used for planning applications to create a binary dependent variable (positive or negative outcome) for use in a binomial logistic regression analysis. Data obtained from the UK Government's Renewable Energy Planning Database (REPD) monthly extract (January 2017). Figures refer to planning applications in their entirety (not individual wind turbines or solar panels).

Development statuses in the REPD classified as 'Positive Outcome'			Development statuses in the REPD classified as 'Negative Outcome'			Development statuses in the REPD classified as 'Unknown Outcome'		
	Wind	Solar		Wind	Solar		Wind	Solar
Planning Permission Granted	95	272	Planning Permission Refused	359	185	Planning Application Submitted	81	23
Appeal Granted	36	40	Appeal Refused	170	92	Planning Application Withdrawn	264	104
Under Construction	65	60	Appeal Withdrawn***	24	4	Appeal Lodged	37	21
Operational	548	902	Secretary of State – Refusal	14	2	Secretary of State – Intervened	4	4
Decommissioned*	6	0	Secretary of State Intervened – Application Refused	1	0	Abandoned	49	37
Planning Permission Expired**	6	3						
Total	756	1277		568	283		435	189

* Decommissioned projects will have had a positive outcome to their planning application in order to reach this stage of their lifecycle.

** Although this infers that the project will not be built, it was nonetheless granted a positive planning outcome at the time of application.

*** For a project to withdraw from appeal, it must have been refused planning consent at least once. Given that the overall outcome is that the project has received planning refusal at least once, and cannot receive consent at a later date, this is classed as a negative outcome.

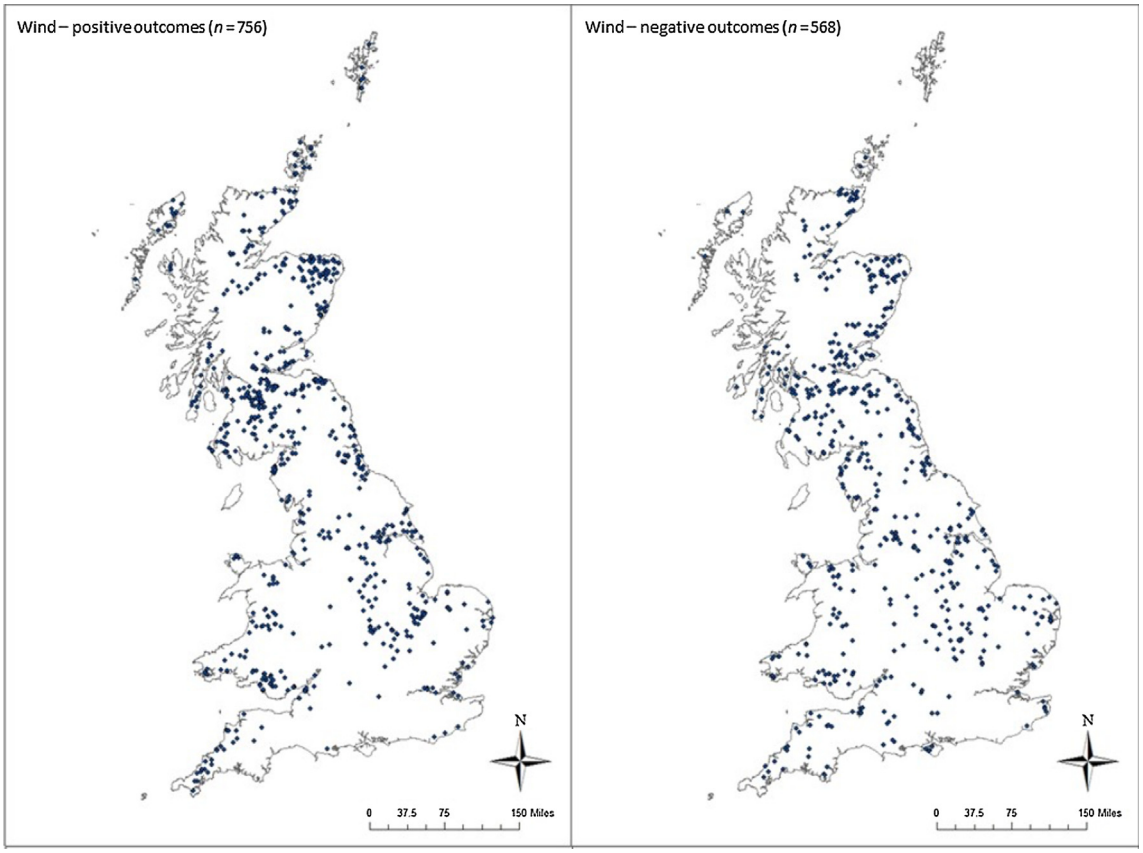

Fig. 2. Positive (left) and negative (right) planning outcomes for onshore wind in Great Britain (1990–2017).

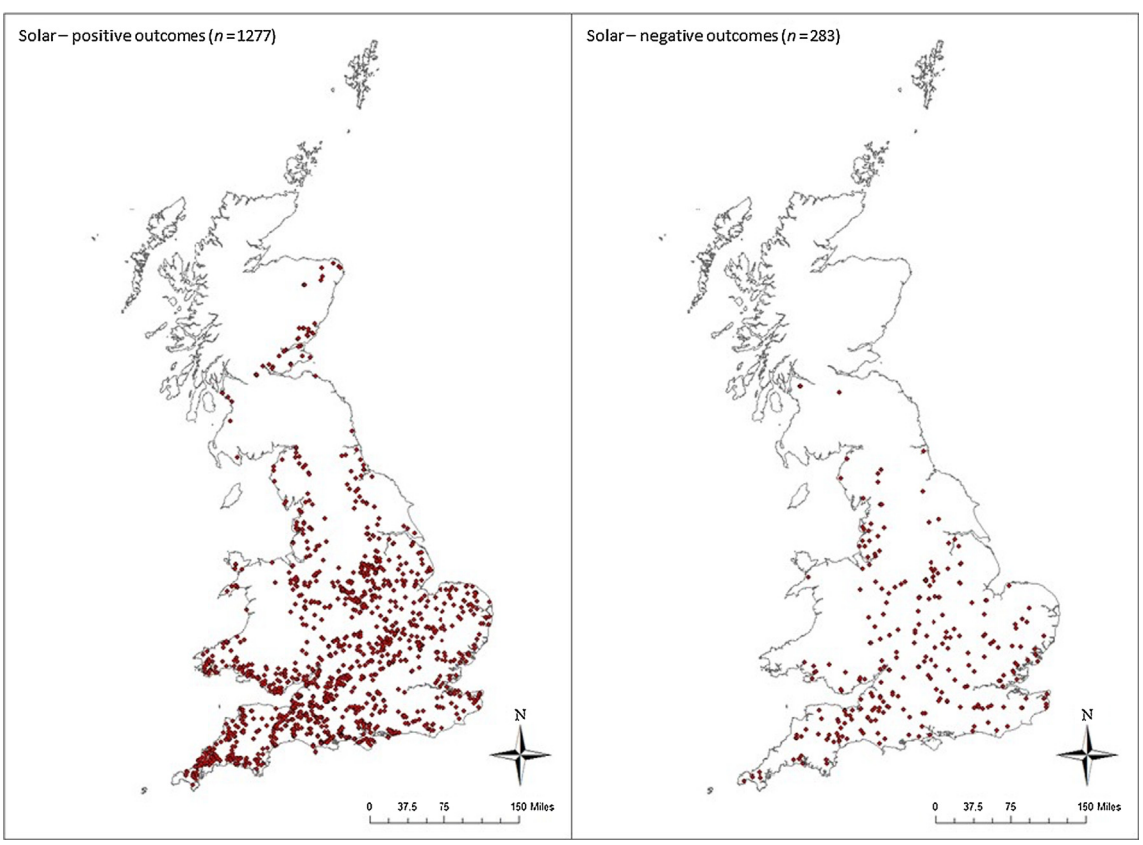

Fig. 3. Positive (left) and negative (right) planning outcomes for solar farms in Great Britain (1990–2017).

within the relevant jurisdiction, the applicant has the right of appeal. In this case, the decision on the appeal is made by decision-makers mandated by central government.

3.2. Data collection

Planning data for onshore wind and solar farms were obtained from the UK Government's Renewable Energy Planning Database (REPD). The database monitors the progress of UK renewable electricity projects above 1 MW capacity (including Combined Heat and Power) through the stages of planning, construction, operation and decommissioning. Records begin in 1990 and are updated on a monthly basis. The monthly extract from January 2017 was used as the basis for this analysis, which includes all applications lodged up until the end of 2016 [60]. To test the community acceptance variables hypothesised to have an effect on planning decisions for these technologies, indicators were compiled using data obtained from a variety of sources (see Table 1). The variables were selected based on the conceptual framework presented in Section 2. It should be noted that community acceptance of onshore wind and solar farms may be affected by other variables than those included in our analysis. However, some variables are not possible to analyse across the whole of GB (e.g. place attachment to non-designated areas that are nonetheless considered scenic by locals), or there is insufficient geospatial data available to quantify them at this scale. Consequently, some variables of potential relevance are not included in this paper's analysis, though could be included in a similar analysis at a local scale.

3.3. Data analysis

To analyse statistical patterns relating to positive and negative outcomes for planning applications, binomial logistic regression was used. Binomial logistic regression predicts the probability that an observation falls into one of two dichotomous categories based on one or more independent variables. This enables statistical analysis of the relationship between the planning outcome (the dependent variable) and a range of independent variables which may have had an influence on this outcome. To produce the required dichotomous dependent variable, projects were categorised either as 'positive', 'negative' or 'unknown' outcome, based on the 'Development Status' provided in the REPD (see Table 2). Positive outcomes refer to cases where a project has been granted consent, whether or not that project is currently constructed and/or in operation, or whether it actually will be constructed (given that the variable of interest is the planning decision itself). Negative outcomes refer to cases where a project has been refused consent, either by the LPA or central government, including cases where an appeal is withdrawn after an application has been initially refused. Projects with an 'unknown outcome' were excluded as it cannot be known whether they would have been (or will be) granted or refused consent. Their exclusion, whilst statistically necessary, could potentially skew results as withdrawn or abandoned projects may correlate with some level of community resistance, leading to their withdrawal.

Centroids of the planning applications were plotted in a Geographic Information System (GIS) and values from each of the datasets in Table 1 assigned to them based on location. Data on the individual configuration of each application are not readily available i.e. the number and layout of individual turbines and solar panels; for the benefit of interpretation, the average area of a wind farm in the dataset used in this analysis is approximately 2.1 km^2 (18.9 MW) and the average area of a solar farm is approximately 0.4 km^2 (8.1 MW), based on the land use estimates for these technologies recommended by Gove et al. [39]. Where possible, the date of the planning application was matched to data from as close a prior time point as possible. For instance, land cover data for GB are available for 1990, 2000, 2007 and 2015. Therefore, planning applications between 1990 and 1999 were assigned the value recorded in the 1990 dataset; planning applications between 2000 and 2006 were assigned the value recorded in the 2000 dataset, and so forth. In cases where data did not cover the whole period 1990–2017, linear extrapolation was used to calculate trends across the full time period of the study. For data on social deprivation, the Townsend Index score was used as it is calculated from census data and is therefore comparable over time, unlike other measures of deprivation [62].

The administrative geography used in this study is primarily Local Authority District (LAD), of which there are 407 in GB, as this is the level at which planning decisions for onshore wind and solar farms are typically made. However, in some instances data were not available at this level, in which case the smallest spatial scale was used at which the data were available: either county (of which there are 140 in GB) or region (of which there are 11 in GB). Since LADs vary in size across GB and in some cases data were not available at LAD level, the Modifiable Areal Unit Problem (MAUP) is of relevance [63]. However, it is not possible to eliminate the problem of MAUP given the nature of the data availability and analysis undertaken. We discuss the implications of this for our results in Section 5. Visualisation of the administrative geographies of GB is available in Supporting Information.

Prior to statistical analysis, data were tested to ensure they complied with the assumptions of binomial logistic regression. All continuous independent variables were found to be linearly related to the logit of the dependent variable by using the Box-Tidwell (1962) procedure and a Bonferroni correction [64]. Multicollinearity between independent variables was measured by the variance inflation factor (VIF), and coefficients with a VIF greater than 2.5 were removed [65] (see Table 1). Outliers were tested using studentized residuals, and cases with a value of 2.5 standard deviations or greater were removed. This resulted in 26 variables (the indicators in Table 1) and 1306 cases included in the wind model, and 24 variables and 1554 cases included in the solar model. Full models were constructed as the variables are based on a conceptual framework which the authors seek to test through this analysis, rather than aiming for a parsimonious predictive model.

4. Results

Plotting the centroids of planning applications from the REPD shows that between 1990 and 2017 there was a concentration of applications for solar farms in the South West of England and Southern Wales, thinning out substantially in more Northerly regions where the solar energy resource is less reliable (see Fig. 3). There was also a cluster of solar farm applications in Eastern Scotland, which receives relatively high amounts of solar radiation compared to other Scottish regions [66]. Applications for onshore wind were more diffuse without a clear spatial pattern (see Fig. 2). Figs. 2 and 3 indicate potentially different geographies for successful and unsuccessful planning applications for these two technologies, although without a clear spatial pattern to differentiate them.

The logistic regression model for onshore wind applications explained 26% (Nagelkerke R^2) of the variance in planning outcomes, and correctly classified 69% of cases. The model for solar farm applications explained 13% (Nagelkerke R^2) of the variance in planning outcomes, and correctly classified 82% of cases. The greater percentage accuracy in classification (PAC) for solar farms, despite the lower Nagelkerke R^2, is explained by the fact that there was less variation in planning outcomes for solar farm planning applications (81% of solar farm applications achieved a positive outcome between 1990 and 2017, compared to 57% of onshore wind applications). Therefore, overall the independent variables included in the model(s) were better able to

Table 3
Significant variables associated with positive planning outcomes for onshore wind planning applications ($p \leq 0.05$).

Category of variable		Acceptance variable	Indicator used for variable	p	Odds Ratio	95% CI for Odds Ratio	
						Lower	Upper
Material arguments	Aesthetic	Impact on scenic recreation	Distance to National Parks (km)	0.000	1.009	1.005	1.014
		Impact on 'wildness'	Remoteness score (1–256)	0.025	1.017	1.002	1.032
			Visibility of modern artefacts and structures score (1–256)	0.000	1.017	1.014	1.021
	Project details	Project size	Installed capacity (MW)	0.031	0.996	0.992	1.000
			Turbine capacity (MW)	0.000	1.476	1.252	1.739
Attitudinal/social influences	Demographic	Social deprivation	Townsend Index score (LAD)	0.042	0.894	0.802	0.996
	Temporal	Exposure to renewable energy infrastructure	Year of planning application	0.001	0.934	0.899	0.971
	Geographical	Geographical location	Population density (LAD)	0.002	1.080	1.030	1.132

Table 4
Significant variables associated with positive planning outcomes for solar farm planning applications ($p \leq 0.05$).

Category of variable		Acceptance variable	Indicator used for variable		p	Odds Ratio	95% CI for Odds Ratio	
							Lower	Upper
Material arguments	Aesthetic	Impact on 'wildness'	Ruggedness score (1–256)		0.000	0.859	0.802	0.921
			Visibility of modern artefacts and structures score (1–256)		0.018	1.006	1.001	1.010
	Environmental	Impact on biodiversity conservation	Distance to SACs (km)		0.040	0.979	0.958	0.999
	Economic	Impact on agricultural production	Grade of agricultural land ($p = 0.032$)	2	0.037	2.127	1.048	4.315
				3	0.003	2.773	1.429	5.380
				4	0.025	2.360	1.116	4.993
				5	0.180	2.571	0.646	10.234
				6 (non-agricultural)	0.004	4.492	1.633	12.357
				(base = 1 i.e. highest grade)				
		Impact on tourism	No. tourist visits (county)		0.021	0.999	0.999	1.000
	Project details	Project size	Installed capacity (MW)		0.009	0.978	0.962	0.994
Attitudinal/social influences	Demographic	Social deprivation	Townsend Index score (LAD)		0.031	1.154	1.013	1.314
	Temporal	Exposure to renewable energy infrastructure	Year of planning application		0.000	0.785	0.690	0.892

explain planning outcomes for onshore wind than for solar farms, despite correctly predicting the dependent variable more frequently for solar farms.

The logistic regression models for both technologies were statistically significant ($p < 0.001$). In terms of the independent variables, 8 of the 26 variables included in the onshore wind model were statistically significant (see Table 3) and 8 of the 24 variables included in the solar model were statistically significant (see Table 4). For onshore wind, the significant variables were: distance to National Parks, remoteness, visibility of modern artefacts and structures, installed capacity, turbine capacity, Townsend Index score of the LAD, the year of the planning application, and population density of the LAD. For solar farms, the significant variables were: ruggedness, visibility of modern artefacts and structures, distance to Special Areas of Conservation (SACs), grade of agricultural land, tourist visits to the county, installed capacity, Townsend Index score of the LAD, and the year of the planning application. The effect of these variables on the likelihood of a planning application having a positive outcome is indicated by the Odds Ratio (OR). If the OR is greater than 1, the odds of a positive planning outcome occurring *increase* by this amount per one unit change (of a continuous variable); if the OR is less than 1, the odds of a positive planning outcome *decrease* by this amount per one unit change (of a continuous variable). For categorical variables, each category is compared to a baseline (i.e. reference) category. For example, categorical grades of agricultural land are compared to the highest grade of agricultural land: the OR increases if the grade being tested is *more* likely to result in a positive planning outcome than the reference category, and decreases if it is *less* likely to result in this than the reference category.

5. Discussion

5.1. The role of community acceptance variables in planning outcomes

Our analysis reveals that variables relating to community acceptance are associated with planning outcomes for onshore wind and solar farms in a statistically significant way. More variables in the 'material arguments' category were significant than those in the 'attitudinal/social influences' category across both technologies, particularly aesthetic variables. This indicates that aesthetics and visual impacts are strongly associated with planning outcomes for both onshore wind and solar farms, which is in line with much of the existing literature on public

acceptance of these technologies (e.g. [35–36,67],. Variables from seven of the eight sub-categories in our conceptual framework Fig. 1 were identified as significant (aesthetic, environmental, economic, project details, demographic, temporal, and geographical). However, no political variables were found to be significant for either of the technologies. Common significant variables (visibility of modern artefacts and structures, installed capacity, Townsend Index score, and the year of the planning application) suggest that the project's visual impact, installed capacity, the social deprivation of the local area, and the time of application are important in terms of planning outcome for both onshore wind and solar farms.

In terms of aesthetic variables, a unit increase in the visibility score (i.e. the score representing the proportion of the viewshed taken up by modern infrastructure such as buildings, roads and pylons) had a positive effect on the likelihood of both technologies achieving planning success. In other words, the less that the project represented a 'new' visual addition to the landscape, the more likely it was to be approved. This effect was stronger for onshore wind, but also applied weakly to solar farms. For onshore wind, a unit increase in the visibility score increased the likelihood by 1.7%, and for solar farms 0.6%. This finding is in line with other environmental planning literature which identifies the presence of 'hazard havens' [68], whereby developments become concentrated within specific areas as it becomes easier to gain planning consent if located near to other similar developments. Similarly, our results suggest that for onshore wind, greater distances from National Parks (which have strict planning regulations relating to visual impacts) increased the likelihood of planning success by 0.9% per km. This suggests that in terms of distributional justice, the visual impacts of onshore wind and solar farms have been concentrated within specific localities of GB.

However, this assumes the visual presence of onshore wind and solar farms to be a 'cost' or 'burden', which it is arguably not in the sense of other environmental ills framed in distributional justice terms, such as exposure to hazardous wastes or pollutants which have known health impacts. There is limited evidence that onshore wind and solar farms cause detrimental health effects, though some studies have highlighted irritations such as the noise of wind turbines (e.g. [69]). Whilst for some people the cultural ecosystem services provided by scenic environments are spoilt by the introduction of onshore wind and solar farms, for other the addition of wind turbines has been noted as an aesthetic addition to the landscape [70]. This highlights the difficulty of quantifying costs and benefits when socio-cultural preferences are involved. Furthermore, deployment of onshore wind and solar farms can in some cases supply benefits to host communities through community benefit packages, to land-owners through land rental agreements or through sales of electricity to the grid, and to local authorities through the accruement of business rates [71,72],. Thus, it is not clear-cut as to whether they are ultimately a cost or a benefit to host communities, and indeed the answer is often highly subjective.

In terms of other aesthetic variables, an increased remoteness score had a positive effect on the likelihood of planning approval for onshore wind, by 1.7% per unit increase. This indicates that despite being more likely to be approved if nearby to other modern infrastructure, it is also more likely to be approved in remote locations, perhaps because remote projects have fewer objections from local communities. An increased ruggedness score decreased the likelihood of planning approval for solar farms by 14.4% per unit increase. However, rather than as a result of aesthetic considerations, this is more likely explained by terrain suitability and accessibility reasons, given that solar farms require relatively level terrain for deployment and access roads for construction. This indicates that aesthetic considerations are more important for onshore wind, given that it has a more prominent visual signature.

Environmental variables were found to be significant for solar farms, though not for onshore wind. Our hypothesis was that concerns around biodiversity and natural habitats would mean that there would be stronger community objections to projects proposed close to protected areas. Counter to this hypothesis however, proximity to Special Areas of Conservation or 'SACs' (protected areas designated under the EU Habitats Directive) had a positive effect on the likelihood of planning consent for solar farms: applications were 2.1% less likely to be approved every 1 km further away they were from an SAC. This may be explained by the suitability of solar farms to rural and semi-rural areas, which are more likely to host protected habitats. The lack of significant findings around other indicators of biodiversity conservation may be due to the fact that protected areas were used as an indicator rather than species distribution, given poor data availability for the latter. This topic would benefit from further research.

Regarding economic variables, the grade of agricultural land had a significant effect on solar farm applications: when compared to the highest grade, proposals made on lower grades of land are between 2.1 and 2.8 times more likely to gain planning consent, and proposals made on non-agricultural land are 4.5 times more likely. This suggests that impacts on agricultural production are being taken into account in decision-making, and solar farms on non-agricultural land are regarded as more acceptable. These findings show that conflicts are arising between land uses in GB, with existing norms around the provision of ecosystem services such as biodiversity protection and agricultural production coming into conflict with renewable energy production, and potentially influencing the acceptability of renewable energy technologies as a result. Increased numbers of tourists staying in the county for one or more night was associated with decreased likelihood of a positive planning outcome for solar farms. This is potentially explained by the concerns around their negative impact on tourism and scenic recreation, or perhaps simply because sunny places attract more tourists and are also more suitable for solar farm development. This effect (whilst statistically significant) was quite weak, with the likelihood of planning approval decreasing by 0.001% per additional tourist visit to the county.

Notably, the results regarding economic variables overlap with demographic variables, given that percentage of home ownership is one of the variables included in the Townsend Index of deprivation. Interestingly, although the Townsend Index score of the LAD was identified as significant for both onshore wind and solar farms, opposite trends were identified across the two technologies: a unit increase in the Townsend score *decreased* the likelihood of planning approval for onshore wind by approximately 10.6%, whilst it *increased* the likelihood of planning approval for solar farms by approximately 15.4%. In other words, the more deprived the local area, the less likely it was for onshore wind applications to be approved, whilst the more likely it was for solar farm applications to be approved.

One interpretation of the trends around social deprivation is that areas with higher social capital are more successful at opposing unwanted developments because they have greater capacity to engage in official planning process processes [51–52]. If this is assumed to be true, these results would infer that solar farm projects are more of an unwanted land use than onshore wind farms, given that solar farm applications are more likely to be *refused* in the wealthiest areas, yet onshore wind farm applications are more likely to be *accepted*. An important implication of these results is that the costs and benefits of onshore wind and solar farm deployment in GB do not appear to be evenly distributed across social groups, with consequences for distributional justice. They also have implications for procedural and recognition justice as they indicate that affluent communities are better represented in official planning processes around renewable energy than less affluent communities, meaning that some types of renewable energy developments are becoming concentrated in deprived areas as a result. Another possible explanation for these trends is that "(ex-) mining or (ex-)industrial communities understand that electricity does not come 'out of the light switch' but has to be produced in a plant somewhere" [73], meaning that people in deprived communities (often overlapping with ex-mining and ex-industrial areas) are more accepting of 'unwanted' energy generation than wealthy communities.

In terms of the characteristics of individual projects, a number of inferences can be made from our results with regards to community acceptance. A unit increase in installed capacity, measured in megawatts (MW), had a *negative* effect on the likelihood of achieving planning consent for both technologies. For onshore wind, an increase of 1 MW capacity decreased the likelihood of a positive outcome by approximately 0.04%; for solar farms, approximately 2.2% per MW. This suggests that smaller onshore wind and solar farm projects are regarded as more acceptable by communities and decision-makers. However, it should be noted that installed capacity does not have a linear relationship with the overall size of a project, given that advances in technology mean that more recent projects may achieve the same capacity (in MW) with fewer individual turbines or solar panels. The installed capacity of a project should, therefore, only be interpreted as an *indication* of the overall project size (i.e. the larger the MW the larger the size of the project). Importantly, the capacity of *individual* wind turbines had a positive effect: for each 1 MW increase in turbine capacity, the likelihood of a positive planning outcome increased by 1.5 times. This suggests that small onshore wind projects with fewer larger turbines are preferable.

In terms of the time at which the planning application is made, each successive year decreased the likelihood of planning success by 6.6% for onshore wind and 21.5% for solar farms. This indicates that rather than becoming more acceptable over time, perhaps a 'saturation effect' is approached. It appears to be more difficult to achieve a positive planning outcome, perhaps due to cumulative impacts and / or perhaps because 'easy win' sites have been used up. Notably, this saturation effect is developing more rapidly for solar farms than it has done for onshore wind: the first application for an onshore wind project in the REPD is in January 1991, whilst the first application for a solar farm project is in December 2010. These findings are counter to our hypothesis that community acceptance (and, in turn, planning acceptance) would become easier over time as the public became acclimatised to renewable energy infrastructure, in contrast to studies which found that attitudes improved with exposure through time (e.g. [54]). However, it could be that community acceptance *has* increased as a result of exposure, but a lack of remaining suitable sites prevented later applications from being successful. Other drivers could also be at play, such as policy changes or the availability of subsidies, which warrant further study.

Finally, the geographical variable of population density was found to be significant for onshore wind. Interestingly, increased population densities were associated with higher likelihood of approval for onshore wind by 8% per unit increase. This contrasts with the finding that increased remoteness also improves the likelihood of onshore wind planning success, suggesting that whilst wind farms are more likely to be located in semi-remote areas they are not likely to be located in the *most* remote areas, presumably due to access and other technical considerations such as connection to the electricity grid. Notably, the country in which the application was made (England, Scotland or Wales) was not found to be statistically significant in explaining planning outcomes, suggesting similar patterns of planning outcome in these different parts of GB. Additionally, the political party in control of the LPA was not found to be significant, suggesting that decision-making and community acceptance is more strongly influenced by the other variables analysed in this study than by political factors. This is somewhat surprising as other studies (e.g. [53] found political values to be important in explaining public support for wind energy. However, when considered alongside the fact that material arguments are found to be more significant than attitudinal/social influences, this indicates that planning decisions cannot be easily swayed by local political values if material arguments aren't also present.

There are limitations to the confidence with which these results can be interpreted as the effect of community acceptance, given that other stakeholders such as NGOs, pressure groups or statutory agencies may feed in similar concerns to the planning process. Planning decisions by LPAs can also be affected by other criteria such as planning regulation, local plans (which set priorities for LADs), or precedent (i.e. by planning decisions made previously with relevance to the current decision). Thus, there is potential collinearity between community acceptance and these other influences on decision-making, which cannot be accounted for in this type of large-scale analysis. Differentiation between such influences requires further in-depth research at a more localised case study level. Importantly, the Modifiable Areal Unit Problem means that the results are only applicable for the geographies used in this analysis. Whilst LADs *are* an appropriate geography, not all variables used in our analysis are available at this scale. More disaggregated data, such as locations of individuals commenting positively or negatively on renewable energy planning proposals, could be a useful extension to the modelling.

5.2. Public acceptance and energy justice

A key question raised by this analysis is the relationship between community acceptance (and public acceptance more broadly defined) and energy justice. Whether renewable energy developments such as onshore wind and solar farms are regarded as a cost or a benefit to host communities is highly subjective. Thus, it is extremely difficult to measure whether a project is 'accepted' by a community or not. It could be argued that communities are able to express their acceptance or non-acceptance through participation in the planning system, yet as shown by this and other studies (e.g. [20], applications are more likely to be approved in areas which are known to be systematically under-represented in formal planning processes. Therefore, improved procedures to better distribute the costs and benefits of low carbon transitions are urgently needed, including incorporating lesser heard voices. Community benefit schemes can also play an important role in distributing the costs and benefits of low carbon transitions, as well as remedying 'injustices' (actual or perceived) in renewable energy deployment, and improving public acceptance at multiple levels.

As Wüstenhagen et al. [33] argue, there are multiple ways to gauge 'acceptance': at the community level (e.g. through participation in planning processes), the socio-political level (e.g. through opinion polls), or at the market level (e.g. through adoption of a technology). This raises a challenge for policymakers in terms of incorporating public acceptance into energy policy, as well as normative questions around whether these measures *should* be considered when formulating policy or if other criteria such as climate mitigation or energy security should override citizens' preferences. In Europe, a significant and positive effect on the rate of renewable energy policy outputs has been found in relation to public opinion on prioritising the environment [74]. This suggests that socio-political acceptance has been an important factor in shaping energy policy in many European countries. However, support for onshore wind and solar in the UK (in the form of financial subsidies, favourable planning regulation and political rhetoric) has been withdrawn despite receiving consistently high scores in the UK Public Attitudes Tracker, with the government instead supporting nuclear power and fracking, both of which have received consistently *low* scores (Barnham, 2017). This indicates that although UK communities may be having some effects on local decisions (as demonstrated by our results), the overall policy-making process is being driven by priorities other than public acceptance.

As Siegrist et al. [75] argue, a comprehensive debate of the trade-offs associated with various energy pathways is a vital aspect of designing an 'appropriate' energy mix, so that public awareness is raised about how protected values (such as landscape values) may need to be re-evaluated in the transition to a low carbon energy system. However, there is also a need to facilitate public input to the policy-making process in order to make it more deliberative, which social science research suggests can help to increase overall acceptance of decisions [76]. This may also go some way to overcoming negative public perceptions of distributional and procedural justice by improving

understanding of the challenges and trade-offs inherent to the low carbon transition, which has in itself been found to have a positive effect on social acceptance of the energy policies and projects necessary to meet the highly complex challenge of decarbonisation [77].

6. Conclusion

This paper investigates the effect of community acceptance on planning applications for onshore wind and planning applications for solar farms in GB between 1990 and 2017. Our approach is novel as there has been limited large-scale analysis of community acceptance of renewable energy technologies, with the few existing empirical studies predominantly focusing on case studies at lower spatial scales. In particular, research on solar farms is significantly lacking in the existing literature. From the public acceptance and environmental planning literature, we construct a novel conceptual framework comprising a set of variables which influence community acceptance of onshore wind and solar farms. Twelve of these variables were identified as statistically significant: four for onshore wind, four for solar farms, and four spanning both. This indicates that different factors influence community acceptance of each technology and their respective planning decision-making processes, although visibility, installed capacity, social deprivation and year of planning application were found in common.

The results of this study have a range of implications for community acceptance and energy justice. Firstly, the findings around social deprivation suggest that solar farm projects are more likely to be sited in deprived areas, whilst onshore wind farms are more likely to be sited in wealthier areas. Although the issue of whether these technologies represent a cost or benefit remains a matter of debate, their uneven distribution across the country has implications for distributional, procedural and recognition justice. Secondly, our findings suggest that aesthetic variables are particularly important in explaining planning outcomes, demonstrating the need for increased public awareness of the range of options and trade-offs involved in future energy pathways so that visual preferences are formulated and balanced within the context of wider energy system change. Finally, the paper also raises the question of whether public acceptance should be a core principle of energy justice. Whilst acceptance can be difficult to measure, its integration into energy decision-making should be considered more closely to achieve a low carbon transition underpinned by fairness and equity. The authors recommend further critical and ethical consideration of this important question within energy justice scholarship.

Acknowledgements

This research was undertaken as part of the UK Energy Research Centre research programme under the Addressing Valuation of Energy and Nature Together (ADVENT) project, funded by the Natural Environment Research Council (NE/M019705/1), United Kingdom. Funding was also received from the School of Geography, University of Leeds, United Kingdom.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.apenergy.2018.05.087.

References

[1] Devine-Wright P. Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review. Working Paper No. 1.4. 'Beyond Nimbyism: a multidisciplinary investigation of public engagement with renewable energy technologies'; 2007. http://www.sed.manchester.ac.uk/research/beyond_nimbyism/.
[2] Fast S. Social acceptance of renewable energy: trends, concepts, and geographies: social acceptance of renewable energy. Geography Compass 2013;7(12):853–66. http://dx.doi.org/10.1111/gec3.12086.
[3] Upham P, Oltra C, Boso À. Towards a cross-paradigmatic framework of the social acceptance of energy systems. Energy Res Social Sci 2015;8:100–12. http://dx.doi.org/10.1016/j.erss.2015.05.003.
[4] Wittneben BBF. The impact of the Fukushima nuclear accident on European energy policy. Environ Sci Policy 2012;15(1):1–3. http://dx.doi.org/10.1016/J.ENVSCI.2011.09.002.
[5] DECC (Department of Energy and Climate Change). Statement on ending subsidies for onshore wind; 2015. https://www.gov.uk/government/speeches/statement-on-ending-subsidies-for-onshore-wind.
[6] Sternberg R. Hydropower: dimensions of social and environmental coexistence. Renew Sustain Energy Rev 2008;12(6):1588–621. http://dx.doi.org/10.1016/j.rser.2007.01.027.
[7] Cotton M. Fair fracking? Ethics and environmental justice in United Kingdom shale gas policy and planning. Local Environ 2016;1–18. http://dx.doi.org/10.1080/13549839.2016.1186613.
[8] Smyth Luke. Adani's Carmichael mine, international law and the definition of consent. Native Title Newsl 2016:6–8.
[9] McCauley DA, Heffron RJ, Stephan H, Jenkins K. Advancing energy justice: the triumvirate of tenets. Int Energy Law Rev 2013;32(3):107–10.
[10] Bullard Robert D. Solid waste sites and the black Houston community. Sociol Inq 1983;53(2–3):273–88. http://dx.doi.org/10.1111/j.1475-682X.1983.tb00037.x.
[11] Freeman III AM. Distribution of environmental quality. In: Kneese AV, Bower BT, editors. Environmental quality analysis: theory and method in the social sciences. Baltimore (MD): The John Hopkins Press; 1972. p. 243–78.
[12] Mitchell G, Norman P, Mullin K. Who benefits from environmental policy? An environmental justice analysis of air quality change in Britain, 2001–2011. Environ Res Lett 2015;10(10):105009. http://dx.doi.org/10.1088/1748-9326/10/10/105009.
[13] Stevens GA, Dias RH, Ezzati M. The effects of 3 environmental risks on mortality disparities across Mexican communities. Proc Natl Acad Sci 2008;105(44):16860–5.
[14] Viel JF, Hagi M, Upegui E, Laurian L. Environmental justice in a French industrial region: are polluting industrial facilities equally distributed? Health Place 2011;17(1):257–62. http://dx.doi.org/10.1016/j.healthplace.2010.10.007.
[15] Bouzarovski S, Simcock N. Spatializing energy justice. Energy Policy 2017;107:640–8. http://dx.doi.org/10.1016/j.enpol.2017.03.064.
[16] Gillard R, Snell C, Bevan M. Advancing an energy justice perspective of fuel poverty: household vulnerability and domestic retrofit policy in the United Kingdom. Energy Res Social Sci 2017;29:53–61. http://dx.doi.org/10.1016/j.erss.2017.05.012.
[17] Healy N, Barry J. Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition". Energy Policy 2017;108(June):451–9. http://dx.doi.org/10.1016/j.enpol.2017.06.014.
[18] Clough E, Bell D. Just fracking: a distributive environmental justice analysis of unconventional gas development in Pennsylvania, USA. Environ Res Lett 2016;11(2):25001. http://dx.doi.org/10.1088/1748-9326/11/2/025001.
[19] Kyne D, Bolin B. Emerging environmental justice issues in nuclear power and radioactive contamination. Int J Environ Res Public Health 2016;13(7). http://dx.doi.org/10.3390/ijerph13070700.
[20] Liljenfeldt J, Pettersson Ö. Distributional justice in Swedish wind power development – an odds ratio analysis of windmill localization and local residents' socio-economic characteristics. Energy Policy 2017;105:648–57. http://dx.doi.org/10.1016/j.enpol.2017.03.007.
[21] Walker G. Beyond distribution and proximity: exploring the multiple spatialities of environmental justice. Antipode 2009;41(4):614–36. http://dx.doi.org/10.1111/j.1467-8330.2009.00691.x.
[22] Todd H, Zografos C. Justice for the environment: developing a set of indicators of environmental justice for Scotland. Environ Values 2005;14(4):483–501.
[23] Davies RA. Environmental justice as subtext or omission: examining discourses of anti-incineration campaigning in Ireland. Geoforum 2006;37:708–24.
[24] Sovacool BK, Heffron RJ, McCauley D, Goldthau A, Jones BR, Sovacool B, et al. Energy decisions reframed as justice and ethical concerns. Nat Energy 2016;1(5):16024. http://dx.doi.org/10.1038/nenergy.2016.24.
[25] Aitken M, McDonald S, Strachan P. Locating "power" in wind power planning processes: the (not so) influential role of local objectors. J Environ Plann Manage 2008;51(6):777–99. http://dx.doi.org/10.1080/09640560802423566.
[26] Gross C. Community perspectives of wind energy in Australia: the application of a justice and community fairness framework to increase social acceptance. Energy Policy 2007;35(5):2727–36. http://dx.doi.org/10.1016/j.enpol.2006.12.013.
[27] Simcock N. Procedural justice and the implementation of community wind energy projects: a case study from South Yorkshire, UK. Land Use Policy 2016;59:467–77. http://dx.doi.org/10.1016/j.landusepol.2016.08.034.
[28] Walker C, Baxter J. Procedural justice in Canadian wind energy development: a comparison of community-based and technocratic siting processes. Energy Res Social Sci 2017;29(May):160–9. http://dx.doi.org/10.1016/j.erss.2017.05.016.
[29] Schlosberg D. Defining environmental justice: theories, movements and nature. Oxford: Oxford University Press; 2007.
[30] BEIS (Department of Business, Energy and Industrial Strategy). Digest of United Kingdom energy statistics 2016; 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577712/DUKES_2016_FINAL.pdf.
[31] Ek K, Persson L, Johansson M, Waldo Å. Location of Swedish wind power-Random or not? A quantitative analysis of differences in installed wind power capacity across Swedish municipalities. Energy Policy 2013;58:135–41. http://dx.doi.org/10.1016/j.enpol.2013.02.044.
[32] van der Horst D, Toke D. Exploring the landscape of wind farm developments; local area characteristics and planning process outcomes in rural England. Land Use Policy 2010;27(2):214–21. http://dx.doi.org/10.1016/j.landusepol.2009.05.006.

[33] Wüstenhagen R, Wolsink M, Bürer MJ. Social acceptance of renewable energy innovation: an introduction to the concept. Energy Policy 2007;35(5):2683–91. http://dx.doi.org/10.1016/j.enpol.2006.12.001.
[34] Apostol D, Palmer J, Pasqualetti M, Smardon R, Sullivan R. The renewable energy landscape: preserving scenic values in our sustainable future. Abingdon, Oxon; New York, NY: Routledge; 2016.
[35] Scognamiglio A. "Photovoltaic landscapes": design and assessment. A critical review for a new transdisciplinary design vision. Renew Sustain Energy Rev 2016;55:629–61. http://dx.doi.org/10.1016/j.rser.2015.10.072.
[36] Wolsink M. Wind power and the NIMBY-myth: institutional capacity and the limited significance of public support. Renew Energy 2000;21(1):49–64. http://dx.doi.org/10.1016/S0960-1481(99)00130-5.
[37] Betakova V, Vojar J, Sklenicka P. Wind turbines location: How many and how far? Appl Energy 2015;151:23–31. http://dx.doi.org/10.1016/j.apenergy.2015.04.060.
[38] Lothian A. Visual impact assessment of wind farms in South Australia. In: New Zealand association for impact assessment conference; 2006.
[39] Gove B, Williams LJ, Beresford AE, Roddis P, Campbell C, Teuten E, et al. Reconciling biodiversity conservation and widespread deployment of renewable energy technologies in the UK. PloS One 2016;11(5):e0150956. http://dx.doi.org/10.1371/journal.pone.0150956.
[40] Brudermann T, Reinsberger K, Orthofer A, Kislinger M, Posch A. Photovoltaics in agriculture: a case study on decision making of farmers. Energy Policy 2013;61(March 2018):96–103. http://dx.doi.org/10.1016/j.enpol.2013.06.081.
[41] Enevoldsen P, Sovacool BK. Examining the social acceptance of wind energy: practical guidelines for onshore wind project development in France. Renew Sustain Energy Rev 2016;53:178–84. http://dx.doi.org/10.1016/j.rser.2015.08.
[42] Gibbons S. Gone with the wind: valuing the visual impacts of wind turbines through house prices. J Environ Econ Manage 2015;72:177–96. http://dx.doi.org/10.1016/j.jeem.2015.04.006.
[43] Krohn S, Damborg S. On public attitudes towards wind power. Renew Energy 1999;16(1–4):954–60. http://dx.doi.org/10.1016/S0960-1481(98)00339-5.
[44] Jensen CU, Panduro TE, Lundhede TH. The vindication of don quixote: the impact of noise and visual pollution from wind turbines. Land Econ 2014;90(4):668–82. http://dx.doi.org/10.1353/lde.2014.0038.
[45] Minelli A, Marchesini I, Taylor FE, De Rosa P, Casagrande L, Cenci M. An open source GIS tool to quantify the visual impact of wind turbines and photovoltaic panels. Environ Impact Assess Rev 2014;49:70–8. http://dx.doi.org/10.1016/j.eiar.2014.07.002.
[46] Warren CR, McFadyen M. Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. Land Use Policy 2010. http://dx.doi.org/10.1016/j.landusepol.2008.12.010.
[47] Bishop ID, Miller DR. Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables ARTICLE IN PRESS. Renew Energy 2007;32:814–31. http://dx.doi.org/10.1016/j.renene.2006.03.009.
[48] Toke D. Explaining wind power planning outcomes: some findings from a study in England and Wales. Energy Policy 2005;33(12):1527–39. http://dx.doi.org/10.1016/j.enpol.2004.01.009.
[49] Ladenburg J, Dubgaard A. Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark. Energy Policy 2007;35(8):4059–71. http://dx.doi.org/10.1016/j.enpol.2007.01.023.
[50] van Rijnsoever FJ, van Mossel A, Broecks KPF. Public acceptance of energy technologies: the effects of labeling, time, and heterogeneity in a discrete choice experiment. Renew Sustain Energy Rev 2015;45:817–29. http://dx.doi.org/10.1016/j.rser.2015.02.040.
[51] Anderson C. The networked minority: how a small group prevailed in a local windfarm conflict. Energy Policy 2013;58:97–108. http://dx.doi.org/10.1016/J.ENPOL.2013.02.048.
[52] Rydin Y, Pennington M. Public participation and local environmental planning: the collective action problem and the potential of social capital. Local Environ 2000;5(2):153–69. http://dx.doi.org/10.1080/13549830050009328.
[53] Bidwell D. The role of values in public beliefs and attitudes towards commercial wind energy. Energy Policy 2013;58:189–99. http://dx.doi.org/10.1016/j.enpol.2013.03.010.
[54] Warren CR, Lumsden C, O'Dowd S, Birnie RV. Green On Green": public perceptions of wind power in Scotland and Ireland. J Environ Plan Manage 2005;48(July 2015):853–75. http://dx.doi.org/10.1080/09640560500294376.
[55] Wilson GA, Dyke SL. Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). Land Use Policy 2016;52:287–96. http://dx.doi.org/10.1016/j.landusepol.2015.12.008.
[56] BEIS (Department of Business, Energy and Industrial Strategy). Energy and climate change public attitudes tracker: wave 21; 2017. https://www.gov.uk/government/statistics/energy-and-climate-change-public-attitude-tracking-survey-wave-21.
[57] Clark Pilita. UK solar power rush sparks local protest; 2013. https://www.ft.com/content/0bc15800-043d-11e3-a8d6-00144feab7de?mhq5j=e5.
[58] DCLG (Department of Communities and Local Government). Consultation and pre-decision matters; 2017. https://www.gov.uk/guidance/consultation-and-pre-decision-matters.
[59] Planning Portal. The decision-making process; 2017. https://www.planningportal.co.uk/info/200126/applications/58/the_decision-making_process.
[60] BEIS (Department of Business, Energy and Industrial Strategy). Renewable energy planning database monthly extract; 2017. https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract.
[61] Carver S, Comber A, McMorran R, Nutter S. A GIS model for mapping spatial patterns and distribution of wild land in Scotland. Landsc Urban Plan 2012;104(3–4):395–409. http://dx.doi.org/10.1016/j.landurbplan.2011.11.016.
[62] Mitchell G, Norman P. Longitudinal environmental justice analysis: Co-evolution of environmental quality and deprivation in England, 1960–2007. Geoforum 2012;43:44–57. http://dx.doi.org/10.1016/j.geoforum.2011.08.005.
[63] Openshaw S. The modifiable areal unit problem. Norwich (England): Geobooks; 1984.
[64] Tabachnick BG, Fidell LS. Using multivariate statistics. 6th ed. Essex (UK): Pearson; 2016.
[65] Midi H, Sarkar SK, Rana S, Midi H, Rana S. Collinearity diagnostics of binary logistic regression model. J Interdisc Math 2010;13(3):253–67. http://dx.doi.org/10.1080/09720502.2010.10700699.
[66] STA (Solar Trade Association). STA Scotland: key facts and statistics; 2016. http://www.solar-trade.org.uk/wp-content/uploads/2016/03/Key-facts-and-statistics-Solar-in-Scotland-v8.pdf.
[67] Pasqualetti MJ, Gipe P, Righter RW. A landscape of power. In: Pasqualetti MJ, Gipe P, Righter RW, editors. Wind power in view: energy landscapes in a crowded world. San Diego: Academic Press; 2002.
[68] Planning for a sustainable environment. Town and Country Planning Association report. London: Earthscan Publications; 1993.
[69] Krogh CME. Industrial wind turbine development and loss of social justice? Bull Sci Technol Soc 2011;31(4):321–33. http://dx.doi.org/10.1177/0270467611412550.
[70] Ellis G, Barry J, Robinson C. Many ways to say "no", different ways to say "yes": Applying Q-Methodology to understand public acceptance of wind farm proposals. J Environ Plan Manage 2007;50(4):517–51. http://dx.doi.org/10.1080/09640560701402075.
[71] Burke M. Solar farms: funding, planning and impacts. House of Commons Library; 2015 [briefing paper]. researchbriefings.files.parliament.uk/documents/CBP-7434/CBP-7434.pdf.
[72] Smith L. Planning for onshore wind farms. House of Commons Library; 2016 [briefing paper].
[73] van der Horst D. NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. Energy Policy 2007;35(5):2705–14. http://dx.doi.org/10.1016/j.enpol.2006.12.012.
[74] Anderson B, Bohmelt T, Ward H. Public opinion and environmental policy output: a cross-national analysis of energy policies in Europe. Environ Res Lett 2017. http://dx.doi.org/10.1088/1748-9326/aa8f80. [in press].
[75] Siegrist M, Sütterlin B, Keller C. Why have some people changed their attitudes toward nuclear power after the accident in Fukushima? Energy Policy 2014;69:356–63. http://dx.doi.org/10.1016/j.enpol.2014.02.026.
[76] Stevenson H, Dryzek JS. The discursive democratisation of global climate governance. Environ Polit 2012;21(2):189–210.
[77] Tabi A, Wüstenhagen R. Keep it local and fish-friendly: social acceptance of hydropower projects in Switzerland. Renew Sustain Energy Rev 2017;68(July 2016):763–73. http://dx.doi.org/10.1016/j.rser.2016.10.006.