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Public acceptance of renewable energy in Great Britain: determinants, dimensions and decision-making

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The candidate confirms that the work submitted is their own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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This thesis follows a publication-based format consisting of three empirical chapters. The work in these three chapters has appeared in publication as:

- Roddis, P., Carver, S., Dallimer, M., Norman, P. and Ziv, G. (2018). The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis. *Applied Energy*, 226, 353-364. https://doi.org/10.1016/j.apenergy.2018.05.087
- Roddis, P., Carver, S., Dallimer, M. and Ziv, G. (2019). Accounting for taste? Analysing diverging public support for energy sources in Great Britain. *Energy Research and Social Science*, 56, 101226. https://doi.org/10.1016/j.erss.2019.101226
- Roddis, P., Roelich, K., Tran, K., Carver, S., Dallimer, M. and Ziv, G. (2020). What shapes community acceptance of large-scale solar farms? A case study of the UK's first 'nationally significant' solar farm. *Solar Energy*, 209, 235-244. https://doi.org/10.1016/j.solener.2020.08.065

As lead author on these publications I was responsible for developing the conceptual framing for each article, establishing research questions and hypotheses, designing the methodology, data collection and analysis, writing the manuscripts and revising them throughout the peer review process. The co-authors Professor Guy Ziv, Dr Stephen Carver and Dr Martin Dallimer (the PhD supervisory team) provided guidance on these aspects and feedback on draft manuscripts. The first empirical chapter uses a dataset collated by co-author, Dr Paul Norman. The analysis in the third empirical chapter was contributed to by Katherine Tran, an undergraduate student who completed a summer placement with me in 2019. Her role was to thematically code a textual dataset based on a prescribed coding framework. The framing of the chapter for publication was advised on by co-author, Dr Katy Roelich.

Rationale for alternative format thesis:

The reasons for selecting an alternative format thesis are threefold.

1) Firstly, public acceptance of renewable energy has multiple dimensions including community acceptance (of specific instances of renewable energy infrastructure) and socio-political acceptance (general attitudes to renewable energy technologies). As such, research on this topic logically falls into multiple discrete studies addressing each of these dimensions using relevant datasets and methods.
2) Secondly, this research area is rapidly developing as renewable energy transitions unfold and public acceptance evolves, lending importance to using the most recent data available: an approach facilitated by conducting multiple discrete studies over time.
3) Thirdly, the thesis draws upon several bodies of literature to construct its theoretical framework, which are relevant to distinct academic communities. An alternative thesis format enables targeted dissemination of results to a series of specialised audiences, thereby creating richer opportunities for interdisciplinary discussion and feedback.

Thesis structure:

The thesis is constructed as follows. An introductory section (Chapter 1) establishes the empirical context of the thesis, a high-level summary of the research context, and details of the research design implemented. This is followed by a review chapter (Chapter 2) covering several bodies of academic literature which are relevant to the topic and which have informed the research presented herein. Both of these sections are included in the thesis only and have not been submitted for publication.

Next, three empirical chapters present findings from three discrete studies i.e. the publications described on page 1. The first of these (Chapter 3) analyses planning outcomes for onshore wind and solar farms in Great Britain, using them as an indicator for characteristics which make projects more or less acceptable to communities at the local level. The second (Chapter 4) analyses public attitudes towards a range of energy sources in Great Britain drawing on data from a government survey, identifying spatial and temporal trends in attitudes as well as determinants of public acceptance at the national level. The third empirical chapter (Chapter 5) presents a case study of the first solar farm in Great Britain to be classified as 'nationally significant' infrastructure, identifying determinants shaping community acceptance of this project and what this reveals about broader trends underlying community acceptance of renewable energy infrastructure.

The penultimate section of the thesis (Chapter 6) synthesises and critically discusses the findings of the empirical chapters and highlights policy recommendations arising from the research. The final section (Chapter 7) provides key conclusions, acknowledges limitations of the work and suggests directions for future research. These two sections appear only in the thesis and have not been published elsewhere. Appendices 1, 2 and 3 provide supporting information for Chapters 3, 4 and 5.

Acknowledgements:

I would like to thank my three PhD supervisors who have provided encouragement, support and feedback throughout: Professor Guy Ziv, Dr Stephen Carver and Dr Martin Dallimer. I would also like to thank Dr Paul Norman for sharing the Townsend Index of Deprivation dataset which he constructed from UK census data. This made an important contribution to the first empirical chapter of this thesis. Warm thanks are also extended to Dr Katy Roelich, Dr Gordon Mitchell and Dr Frances Drake for providing helpful feedback during my Annual Progress Review meetings.

On a personal note, I would like to thank my wife Harriet Thew for being a constant sounding board and voice of reason when I couldn't make sense of my research! It has been a pleasure to be part of the Energy and Climate Change Mitigation (ECCM) Research Group and Governance Reading Group, thank you to everyone in these groups who made me feel a valued part of an academic community. Finally, thanks are extended to those who I interviewed for the third empirical chapter of the thesis, without whom I would not have gained the personal insights presented therein.

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Abstract:

This thesis provides an in-depth understanding of how public acceptance of renewable energy (RE) in Great Britain (GB) can be described, understood and explained. It identifies key determinants of public acceptance of RE across multiple dimensions of acceptance: localised responses to RE infrastructure (community acceptance) and generalised attitudes to technologies (socio-political acceptance). It also explores the relationship between public acceptance and RE decision-making.

To do this, it draws upon previously overlooked datasets: the UK Renewable Energy Planning Database (REPD) and the UK Energy and Climate Change Public Attitudes Tracker (PAT). It also conducts a case study of the first solar farm in GB to be classed as a Nationally Significant Infrastructure Project (NSIP): Cleve Hill Solar Park. This combination of research approaches, utilising quantitative and qualitative methods, allows for both breadth and depth of analysis of the research phenomenon.

The thesis makes several empirical contributions including insights into planning outcomes for onshore wind and solar farms, spatial and temporal trends in public attitudes, and identification of determinants of public acceptance of RE. It also identifies the influence public acceptance has on RE decision-making in different GB contexts including local planning, national planning, and national policymaking.

Additionally, the thesis makes theoretical contributions by integrating disciplinary perspectives on this research topic and proposing a novel theoretical framework: the three 'I' model. This framework proposes that public acceptance of RE is shaped by a variety of determinants relating to *infrastructure*, *impacts* and the *individual*.

Finally, the thesis considers the broader implications of its findings for GB's low carbon energy transition. It makes recommendations on how sensitive planning, deliberative processes and community benefit funds could help to increase public acceptance, as well as how measurement of public acceptance could be improved to better design and implement RE transitions that are sensitive to public preferences.

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Acronyms and Abbreviations

ADVENT – Addressing Valuation of Energy and Nature Together

AONB – Areas of Outstanding Natural Beauty

BBC – British Broadcasting Corporation

BEIS – UK Department for Business, Energy and Industrial Strategy

BIS – UK Department for Business, Innovation and Skills

CCC – UK Committee on Climate Change

CCS – Carbon Capture and Storage

CfD – Contracts for Difference

Cleve Hill – Cleve Hill Solar Park

Conservative – UK Conservative and Unionist Party

CSP – Concentrated Solar Power

DECC – UK Department of Energy and Climate Change

DCLG – UK Department for Communities and Local Government

DUKES – Digest of UK Energy Statistics

EA – Environment Agency for England

EEA – European Environment Agency

EIA – Environmental Impact Assessment

ES – Ecosystem Services

EU – European Union

FiTs – Feed-in Tariffs

GB – Great Britain

GHG – Greenhouse Gas

GIS – Geographical Information System

GW – Gigawatts

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

kW – Kilowatts

LAD – Local Authority District

LPA – Local Planning Authority

LSOA – Lower Super Output Area

LVIA – Landscape and Visual Impact Assessment

MK – Mann-Kendall

MAUP – Modifiable Areal Unit Problem

MW – Megawatts

NGO – Non-Governmental Organisation

NPPF – National Planning Policy Framework

NIMBYism – Not in My Backyard-ism

NPS – National Policy Statement

NSA – National Scenic Area (Scotland)

NSIP – Nationally Significant Infrastructure Project

OGA – Oil and Gas Association

ONS – Office for National Statistics

OR – Odds Ratio

Ordinal regression – Ordinal logistic regression

PAT – UK Energy and Climate Change Public Attitudes Tracker

PAC – Percentage Accuracy in Classification

PV – Photovoltaics

RE – Renewable Energy

REPD – Renewable Energy Planning Database

RO – Renewables Obligation

RSPB – Royal Society for the Protection of Birds

SAC – Special Area of Conservation

SBS – Shifting Baseline Syndrome

SNP – Scottish National Party

SPA – Special Protection Area

STA – Solar Trade Association

SSSI – Site of Special Scientific Interest

UK – United Kingdom

UKERC – UK Energy Research Centre

US – United States of America

UN – United Nations

VIF – Variance Inflation Factor

1. Introduction

1.1. Empirical context

Given the severe threat posed by climate change to societies, economies and the natural environment (IPCC, 2018), a transformation of energy systems is taking place across the globe. Energy production and usage is the top contributor to greenhouse gas (GHG) emissions which cause anthropogenic climate change (IEA, 2019). It is widely accepted that renewable energy (RE) technologies and sources such as wind, solar, bioenergy, wave and tidal power are crucial to reducing emissions from this sector, either as part of a 100% RE system or alongside other low carbon technologies such as nuclear power and Carbon Capture and Storage (CCS) (Berkhout *et al*., 2012). Additionally, RE has many co-benefits such as contributing to social and economic development, reducing the health impacts of energy generation, and improving energy access and security (IPCC, 2011).

As such, RE deployment has risen rapidly over the last thirty years, and this must continue at an even greater pace in order to meet targets of limiting average global temperature rise to 1.5°C by 2100, as mandated by the United Nations (UN) Paris Agreement (McCollum *et al*., 2018). However, a potential barrier to the large-scale deployment of RE is a lack of public acceptance. In Great Britain (GB), the geographical focus of this research[1], onshore wind has provoked the most high-profile public controversy. Other RE technologies have not received such prominent backlash, though there has been some level of resistance to other RE infrastructure such as ground-mounted solar photovoltaics (PV) or 'solar farms' (Clark, 2013).

The percentage of GB's energy consumption generated by RE sources has been rapidly increasing in recent years, particularly in the electricity sector. The most recent comprehensive data shows that for the United Kingdom (UK) as a whole, renewables' share of electricity generation has increased from 3.6% in 2004 (Bolton,

[1] This thesis focuses on Great Britain (England, Scotland and Wales) rather than the whole of the United Kingdom due to data incommensurability between GB countries and Northern Ireland.

2008) to 37.1% in 2019 (DUKES, 2020). Progress has been slower in the heat and transport sectors, meaning the overall percentage of energy consumption from renewable sources was 12.3% in 2019 (DUKES, 2020), up from 1.3% in 2005 (EEA, 2019). The most widely deployed type of RE in GB is wind energy, which in 2019 accounted for 54% of the UK's total renewable electricity generation (Figure 1). This includes onshore wind (27%) and offshore wind (27%). This is followed by bioenergy (31%), solar PV (11%) and hydro (5%), the latter category including shoreline wave and tidal, though at present these are mostly small-scale demonstration projects.

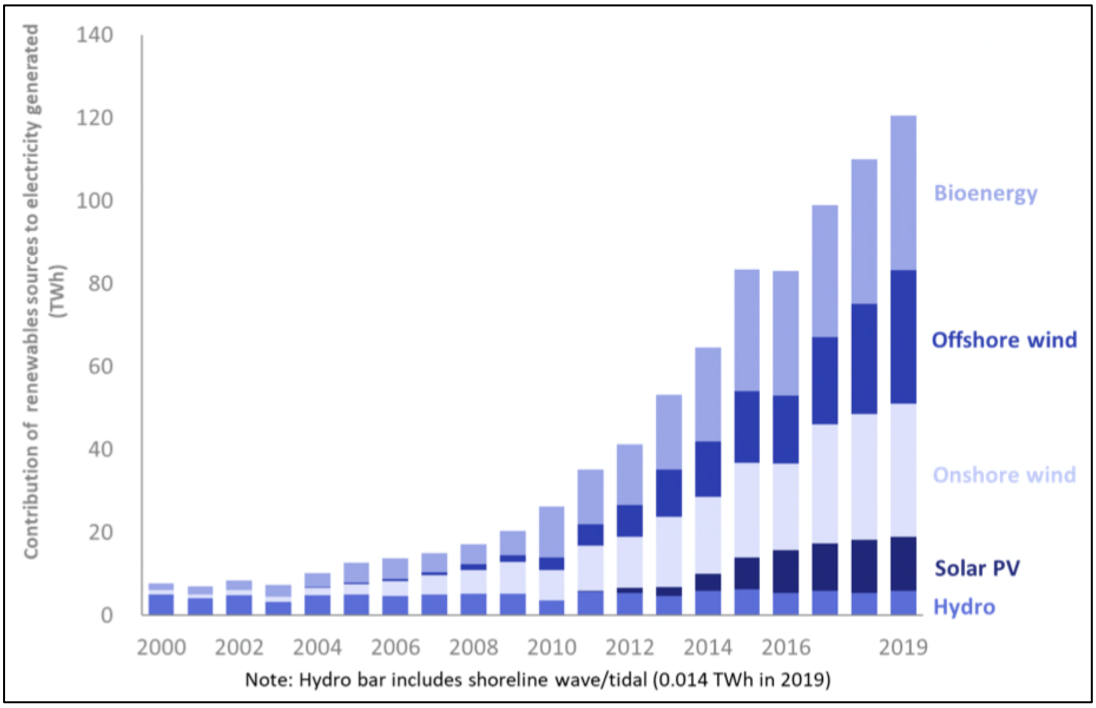

Figure 1. UK renewable electricity generation by source 2000-2019 (DUKES, 2020)

The growth in RE deployment in GB has been driven by a number of policies and targets including the European Union (EU) Renewable Energy Directive 2009, which set a target for the UK to source 15% of all energy and 10% of transport fuels from renewables by 2020 (UK Parliament, 2016). In June 2019, the UK Government passed legislation committing to net zero GHG emissions by 2050 (BEIS, 2019). This extends the previous 2050 target of an 80% GHG reduction set by the UK Climate Change Act 2008, which has acted as a key driver of the UK's climate mitigation efforts given its legally binding nature and five-yearly stepwise targets (Lockwood, 2013). Additionally, in September 2019 the Scottish Government set a legally binding target of net zero GHG emissions by 2045 (BBC, 2019) and Wales has a commitment to reduce GHG emissions by 95% by 2050 with the ambition of reaching net zero by this time (Welsh Government, 2019). Modelling suggests that to achieve the UK's net zero targets, 100 GW of new wind and solar capacity will be required by 2050, rising from around 33 GW at present (Aurora, 2019). As such, transitions to RE are taking place across GB and will continue in the coming decades.

Figure 2. Image showing typical examples of a solar farm and onshore wind farm in Great Britain (Westmill Solar Park and Westmill Wind Farm in Wiltshire, England). Image taken by Richard Peat and obtained via RTPeat on Flickr (CC BY-NC-ND 2.0).

1.2. Research context

In terms of existing research on this topic, the majority of academic literature to date has focused on public acceptance of onshore wind (Fast, 2013; Gaede and Rowlands, 2018). A recent bibliographic review demonstrates that the dominant 'research front' in this field is what the authors term 'wind power / attitudes / NIMBY' (Gaede and Rowlands, 2018). Whilst once a dominant frame and still quite common outside of academia, NIMBYism (Not In My Back Yard-ism) is now widely regarded as an unsatisfactory characterisation of public responses to energy infrastructure. As described by a prominent scholar in this field of research, it assumes that people support an energy source in principle, but in practice do not want to host it in their local area (van der Horst, 2007). However, this overlooks a range of other nuances shaping public acceptance of RE (van der Horst, 2007) and can sometimes be used as 'a succinct way of discrediting project opponents' (Burningham, 2000, p.55).

This thesis thus seeks to move beyond concepts of NIMBYism towards a more complex understanding of the factors shaping public acceptance of RE. It focuses on a range of RE types with an emphasis on onshore wind (to enable cross-comparison with existing studies) as well as solar farms: a technology that has been largely overlooked in existing research despite rising deployment levels. It also considers offshore wind, bioenergy, solar PV (in general) and wave/tidal technologies (see further explanation in Section 1.3 on research design). The thesis therefore offers a broad representation of public acceptance of RE across the technology spectrum, which is valuable as low carbon transitions are likely to include multiple types of RE.

Drawing upon the influential framework by Wüstenhagen *et al*. (2007), the thesis considers two dimensions of public acceptance: 'community acceptance' of RE infrastructure and 'socio-political acceptance' of RE technologies/sources. This provides a multi-faceted analysis of public acceptance, rather than limiting itself to just one dimension. It draws upon a wide range of academic literatures to provide a broad view of the relevant factors shaping public acceptance of RE across these dimensions. This is valuable as studies in the existing literature on public acceptance of RE tend to adopt a particular conceptual perspective, meaning there is a gap in terms of the integration of interdisciplinary perspectives to provide a holistic synthesis of determinants of public acceptance (see Section 2 for further details).

Additionally, the thesis considers how public acceptance influences RE decision-making in GB: a topic that has been largely overlooked in existing research. There is a common assumption in much academic literature as well as public discourse that a lack of public acceptance acts as a barrier to the deployment of RE and thus low carbon transition processes. Yet, the actual influence of public acceptance on decision-making has not been thoroughly analysed or the implications of these dynamics fully explored. This is a research gap that this thesis contributes to, alongside its focus on determinants of public acceptance of RE across dimensions.

1.3. Research design

1.3.1. Aim, research questions and objectives

The overarching aim of this thesis is to provide an in-depth understanding of how public acceptance of RE in GB can be described, understood and explained.

To achieve this aim, the thesis responds to the following three research questions:

1) What are the key determinants shaping public acceptance of RE in GB?
    a. Community acceptance (onshore wind, solar farms)
    b. Socio-political acceptance (onshore wind, offshore wind, solar, bioenergy, wave/tidal energy)
2) To what extent does public acceptance of RE (community and socio-political) influence RE decision-making in GB?
3) What are the implications of the above findings for GB's low carbon energy transition?

To answer these research questions, the thesis is guided by four research objectives:

- To identify key determinants of public acceptance of RE in GB (both community acceptance and socio-political acceptance)
- To develop an interdisciplinary theoretical framework to articulate key determinants of public acceptance of RE
- To understand the extent to which different dimensions of public acceptance influence RE decision-making in different contexts in GB
- To critically analyse the findings of the thesis and infer implications for GB's low carbon energy transition

Different types of RE are investigated in terms of socio-political and community acceptance because of the different data and methods used for each. For community acceptance, two RE sources are focused on: onshore wind and solar farms, addressed in Chapters 3 and 5. These have been selected because: 1) onshore wind is the most widely deployed *and* publicly controversial RE source in GB, making it an important case study; 2) little research has been done on public acceptance of solar farms despite their rapid rise in deployment in recent years. Both technologies are widely deployed in GB, so are very relevant to policy debates. Data was gathered from the UK Renewable Energy Planning Database (REPD) for Chapter 3, and through primary data collection on the Cleve Hill Solar Park case study in Chapter 5.

For socio-political acceptance, five RE sources are explored: onshore wind, offshore wind, solar, bioenergy, and wave/tidal. These are focused on as they are the sources included in the UK Energy and Climate Change Public Attitudes Tracker (PAT), the dataset used in Chapter 4 of this thesis. It also considers socio-political acceptance of nuclear and fracking to compare and contrast with RE, though it is acknowledged that these energy sources involve a different set of public acceptance issues, so the analysis presented is not intended to be comprehensive. Instead, their inclusion helps to provide a broader perspective on the UK's energy policy landscape and the policies and technologies which are playing a role in the UK's low carbon transition.

1.3.2. Rationale for the thesis

In terms of its academic rationale, the thesis is motivated by the aim to contribute empirical and conceptual insights to the scholarly literature on public acceptance of RE. Empirically, it firstly contributes by utilising previously overlooked datasets: the REPD and the PAT. Both datasets provide rich insights into public acceptance of RE but have not been previously used for academic research. Each contain observations going back over a substantial period of time (1990 and 2012 respectively), enabling temporal trends to be identified – something which is highlighted by scholars in this field as an important research agenda in public acceptance of RE (e.g. Rand and Hoen, 2017). They also contain geospatial data, additionally enabling analysis of spatial trends in public acceptance of RE. Secondly, the thesis makes empirical contributions by focusing on technologies which are largely absent in the literature, namely solar farms, which have been under-researched globally and especially so in the GB context. Thirdly, the thesis offers empirical contributions on the relationship between public acceptance and RE decision-making in GB. This is an aspect of energy transitions research with potentially significant implications, but which has currently not been thoroughly explored in the existing scholarly literature.

Conceptually, the thesis is motivated by the aim to integrate interdisciplinary perspectives on public acceptance of RE. Whilst public acceptance of RE research has grown rapidly in recent years (Gaede and Rowlands, 2018), there remain gaps in terms of the integration of interdisciplinary perspectives. Public acceptance of RE is a highly interdisciplinary research topic, yet studies often do not combine multiple disciplinary perspectives. This thesis takes an interdisciplinary approach and combines insights from the range of literatures presented in Section 2 to develop an integrated approach to analysing public acceptance of RE. Thus, alongside its empirical contributions, it offers conceptual contributions by demonstrating how multiple literatures can be brought into dialogue with one another to generate richer, more productive insights. This dialogue is important as these disciplinary perspectives have cross-cutting implications which may otherwise be overlooked.

In terms of the applied, policy-orientated rationale for the thesis, public acceptance is widely considered to be an important factor in successful RE transitions, which are a necessary response to the urgent challenge of climate change (Devine-Wright, 2009). Improved understanding of public acceptance may help to recognise potential issues or blockages in RE deployment, inform policy design, identify how RE interventions are likely to be received by social groups, and ultimately help to plan and manage RE transitions in a smooth and rapid way. It is also likely to reduce uncertainty in how low carbon transition policies play out in the real world, which is particularly important given that 'public attitudes have been identified as one of the most important systemic uncertainties that will affect the successful achievement of UK energy policy' (Hooper *et al*., 2018, p. 405). As public acceptance scholar Hilary Boudet (2019, p. 446) writes in a review paper of energy perceptions:

> *'Although knowledge about public perceptions and responses does not guarantee acceptance or adoption, its absence is likely to result in failure.'*

This quote neatly summarises the instrumental rationale(s) underpinning public acceptance research, which this thesis holds alongside its academic motivations.

Beyond the instrumental rationales described above, there are normative rationales underpinning public acceptance research such as democracy, trust and legitimacy.

For instance, the British public directly contributes to RE policies through a levy on energy bills (Evensen *et al*., 2018). There is therefore a democratic argument in favour of pursuing energy policies that are supported by the public, given they are providing financial support towards it. Beyond this financial rationale, it can also be argued that in a democratic country, elected decision-makers should enact policies that are supported by their constituents, particularly if they are elected on a platform to do so. Not doing so (or pursuing policies that they do not have a public mandate for) may erode trust in decision-making institutions and potentially undermine the political legitimacy of low carbon transitions (MacArthur, 2015). These normative rationales also motivate the thesis alongside its other objectives.

1.3.3. Research approach

This thesis utilises two research approaches: secondary data analysis (Chapters 3 and 4) and case study (Chapter 5). Secondary data analysis is analysis of data that has been collected and tabulated by other sources, such as government agencies (Bhattacherjee, 2012). This was selected because there are two governmental datasets that are relevant to the research topic which have previously been overlooked in academic research: the REPD and the PAT. Each of these have been collected over a number of years (since 1990 and 2012 respectively) and contain geographical data. Analysis of these datasets therefore provides a unique opportunity to understand trends in public acceptance of RE in GB over time and across space. In the case of the PAT, geographical data was not publicly available so was accessed through the Office for National Statistics (ONS) Accredited Researcher Scheme, following a successful application to be granted access to this data (Appendix 2). The secondary data analysis research approach allows for broad characterisations and general trends to be identified for a population of interest.

A case study is an in-depth investigation of a research phenomenon in a real-life setting (i.e. case). Data can be collected using a variety of methods such as interviews, observations and document analysis, and can be either quantitative or qualitative. A key strength of case research is that it allows aspects of a phenomenon to be discovered that may not be known in advance (Bhattacherjee, 2012). It therefore provides a good balance to the secondary data analysis research design as it allows theory to be developed as well as applied and tested (George and Bennet, 2004). Social science theorist Robert K. Yin defines a case study as 'an investigation of a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident' (2009, p. 638). By using case research in this thesis, alongside secondary data analysis, the phenomenon of public acceptance of RE can be investigated in its real-life context as well as through exploration of broader generalised trends. Together, these two research approaches therefore enable both breadth and depth of analysis of the research topic.

Each of these research approaches draws upon observational data rather than data generated through experimental conditions. This means the conclusions drawn by this thesis predominantly apply to relatively large, privately owned RE because this is currently the dominant mode of deployment in GB. This also informs the selection of Cleve Hill Solar Park as a case study (i.e. a large, privately owned RE project) in order to enable comparability. Other types of RE are considered in some instances. For example, Chapter 3 uses 'project size' and 'ownership' (private vs community) as independent variables in the statistical analysis of planning outcomes for onshore wind and solar farms to identify how this interacts with community acceptance. In the main, however, the research lends itself to insights into large-scale, private RE.

The secondary data analysis components of the thesis follow a deductive research approach, whereby research hypotheses are formulated based on a conceptual framework and tested on empirical data. The case study component of the thesis follows an abductive research approach whereby a conceptual framework is applied with a view to modifying it and thus developing new theory (Bryman, 2012). The process for developing the three 'I' theoretical framework for understanding public acceptance of RE (i.e. the thesis' main theoretical contribution) is depicted in Figure 3 below. The framework was first developed from a literature review (Chapters 2 and 3), tested deductively in Chapters 3 and 4, then tested abductively in Chapter 5, before being refined and the final version presented in Chapter 6 (Figure 19).

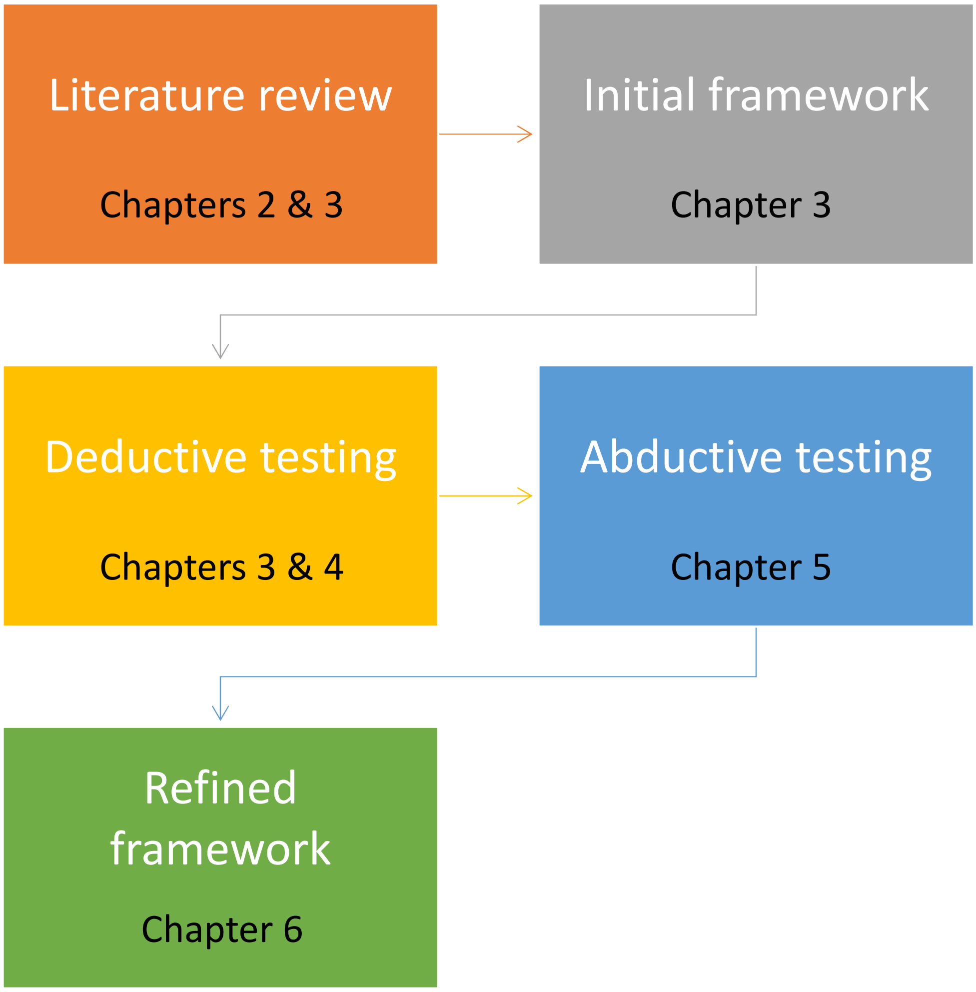

Figure 3. Process for building the three 'I' theoretical framework for understanding public acceptance of RE (i.e. the main theoretical contribution of the thesis)

1.3.4. Research methods

The thesis takes a mixed methods approach to address its research questions, combining quantitative and qualitative research methods. This follows the recommendation from Haggett and Toke (2006) who argue that research on public acceptance of RE can benefit from using quantitative and qualitative methods to 'illuminate different but complimentary aspects of the issue' (p. 104). Similarly, Boudet (2019) argues that multiple measures of public acceptance can be helpful to fully capture the complexity of public acceptance processes. Specifically, this thesis uses the research methods of *statistical analysis*, *spatial analysis*, *content analysis*, *semi-structured interviews* and *participant observation* to holistically investigate the research topic of public acceptance of RE in GB.

The first empirical chapter of the thesis (Chapter 3) uses statistical analysis to identify variables associated with planning outcomes for onshore wind and solar farms in GB. It uses the REPD and a range of other quantitative datasets to construct a new, multivariate dataset cataloguing the characteristics of all onshore wind and solar farm planning applications in GB from 1990 to 2017. It then conducts binomial logistic regression to identify project characteristics which have a statistically significant relationship with successful and unsuccessful planning outcomes. By using planning outcomes as an indicator of community acceptance, this research offers unique empirical insights into which types of onshore wind and solar farms are more likely to achieve planning success, identifies potential explanations for these trends, and discusses what can be inferred about which projects are more and less acceptable to the public. This provides evidence to directly answer the first research question in relation to onshore wind and solar farms, and the second research question with a focus on local planning decisions. Collectively, this enables exploration of the thesis' third research question on broader implications (Table 1).

The second empirical chapter (Chapter 4) uses a range of analytical techniques to investigate the PAT dataset. It uses spatial analysis to identify spatial variation in public attitudes to energy sources across GB, time series analysis to identify temporal trends in this data (2012-2016), and ordinal logistic regression analysis to identify key predictors of support for different energy sources. This involved combining the PAT dataset with a range of other national datasets to create a range of new independent variables that could be tested in the analysis. As with Chapter 3, this analysis provides evidence to directly answer the first research question (this time in relation to onshore *and* offshore wind, solar (in general), bioenergy, wave and tidal energy) and the second research question, this time with a focus on national policy decisions. Taken together, this further enables exploration of the thesis' third research question on broader implications (Table 1).

The third empirical chapter (Chapter 5) uses a combination of content analysis of online comments, semi-structured interviews and participant observation to investigate community acceptance of a solar farm project: Cleve Hill Solar Park. Online responses to the planning proposal submitted by the public were quantitively analysed and triangulated through the qualitative analysis of interview data from local residents and other key stakeholders (campaigners and planning officials). Participant observation at three public hearings and an official site inspection enabled further contextualisation of the research data, plus the opportunity to recruit interview participants. This chapter provides evidence to answer the thesis' first research question in relation to solar farms and the second research question in relation to national planning decisions. As with the other chapters, this chapter also provides evidence to further contribute to the third research question (Table 1).

Table 1. Matrix showing how the thesis' overarching research questions are addressed across the chapters

Question	Chapter 3	Chapter 4	Chapter 5
1. What are the key determinants shaping public acceptance (community and socio-political) of RE in GB?	Community acceptance: onshore wind, solar farms	Socio-political acceptance: onshore/offshore wind, bioenergy, wave/tidal, solar	Community acceptance: solar farms
2. To what extent does public acceptance influence RE decision-making in GB?	Local planning processes	National policymaking	National planning processes
3. What are the implications for GB's energy transition?	Critical analysis of findings from Chapters 3, 4 and 5 (discussed in Chapter 6)		

It should be noted that more specific research questions and/or hypotheses are also sometimes addressed in the empirical chapters (Chapters 3, 4 and 5). The matrix shown in Table 1 depicts the overarching research questions of the thesis (see Section 1.3.1) in order to demonstrate how answering each of them is achieved.

1.3.5. Research philosophy

This thesis is guided by a critical realist research philosophy. Critical realism seeks to bridge the gap between the positivism of natural science and the interpretivism of social science. It does so by adopting the assumption that there is one reality (ontological realism) which is a key position in positivism, alongside the assumption that each individual has their own perception of this reality, thereby incorporating the interpretivist assumption of 'multiple realities' (Healy and Perry, 2000). As Krauss (2005) explains: 'The concept of reality embodied within realism is thus one extending beyond the self or consciousness, but which is not wholly discoverable or knowable' (p. 761). The assumption made by this thesis is therefore that there is one ontological reality containing objective events and processes, but how people experience and interpret that reality is unique, individual and subjective.

A critical realist position helps to bridge the quantitative-qualitative 'divide' which has traditionally been assumed in scientific and social-scientific research. This is because it allows multiple epistemologies (philosophies of how we come to know about the world) and is therefore consistent with both quantitative and qualitative methods. Under the critical realist paradigm, the choice of method is informed by 'the level of existing knowledge pertaining to it' (Krauss, 2005, p. 762), rather than through a fixed epistemology about the appropriate method(s) used to generate knowledge. As Sovacool *et al*. (2018) describe, there is 'no preference for a particular method – choice depends upon the research question and the nature of the relevant entities and causal mechanisms. Mixed methods encouraged' (2018, p. 15).

A critical realist position thus underpins the choice of research approach and methods utilised in this thesis, using quantitative techniques where there is already scientific knowledge established, combined with more exploratory qualitative techniques when less is known about the research topic in question. For instance, public acceptance of solar farms has been largely overlooked in existing literature, rationalising the choice of qualitative research methods alongside quantitative analysis when exploring this specific aspect of the thesis' research topic.

1.3.6. Researcher positionality

As argued by Philip J. Dobson (2002): 'The critical realist agrees that our knowledge of reality is a result of social conditioning and, thus, cannot be understood independently of the social actors involved in the knowledge derivation'. As a matter of rigour, the critical realist epistemology therefore calls for critical reflection on positionality to ensure the research is 'value cognizant' (Krauss, 2005). This infers that the topics I focus on in this thesis, the data collected, and the lenses I use to analyse the data are consciously and unconsciously shaped by past experience and values. This section therefore considers my positionality as a researcher and identifies three key influences which may have shaped this thesis: my academic background; my professional experience; and my personal characteristics.

Although focused on a different academic discipline, my undergraduate degree in English Literature at the University of Edinburgh has certainly shaped my approach to research. For instance, it taught me to situate claims within the understanding of subjectivity and to engage with topics with an understanding of their historic and cultural specificity. It also instilled in me a foregrounding of the researcher as an active participant in the analytical process through interpretation of data and results.

My Masters degree in Environment, Development and Policy at the University of Sussex gave me a solid grounding in environmental social science and the ability to apply critical thinking to contemporary environmental debates. It also sparked an interest in environmental justice issues which has continued during my PhD, as well as a keen interest in climate change, renewable energy and low carbon transitions.

Following completion of my Masters, I worked in the Sustainable Development Policy Team at the Royal Society for the Protection of Birds (RSPB), conducting research identifying suitable sites for deployment of RE in the UK to reduce negative impacts on biodiversity. The project I managed, Energy Futures, demonstrated that whilst it is technically possible for the UK to transition to RE whilst protecting wildlife, there are likely to be trade-offs in terms of other environmental, social and economic impacts. This deepened my interest in the social acceptability of energy transitions and my consideration of winners and losers in climate change mitigation.

Collectively, this past experience is likely to have shaped my approach to this thesis in that I have a strong normative belief in the necessity of RE transitions as a response to climate change, with the perspective that they must be carefully managed to avoid further entrenching existing environmental, social and economic problems. In one case, my past experience came directly into contact with my PhD research: when collecting primary data on Cleve Hill Solar Park for Chapter 5, I encountered an interviewee who had strong negative feelings on the role of the RSPB in the planning process. I did not disclose that I had formerly worked for them as I endeavoured to maintain researcher neutrality and did not want to influence the interview. However, this interaction potentially influenced my interpretation of this data as the interviewee's perception of RSPB's role in the planning process did not align with my experience. This demonstrated to me that it is not possible to remove oneself completely from a topic of research you are professionally embedded within as you may have insider knowledge which shapes your analysis of research data.

Positionality may also have played a role in how other interviewees responded to questions. Similarities and differences between the researcher and 'the researched' can influence what is and isn't disclosed by shaping whether the researcher is perceived as an 'insider' or an 'outsider' (Merriam *et al.*, 2001). As white and middle class, I was likely perceived by most participants as an insider, at least on a superficial level; however, my northern accent and position as a researcher from the University of Leeds denoted me as an outsider. This had an advantage as it meant interviewees did not see me as someone embroiled in local politics and were therefore willing (and in some cases eager) to put across their version of events; however, as an outsider to the local area I was not always able to interpret their responses with an insider's insight. I endeavoured to mitigate this by speaking to a range of people with different perspectives; following discussions on social media; and reading local news reports. However, this cannot be mitigated entirely. These reflections have been provided for transparency and to help the reader assess the validity of my analysis.

1.4. References

BBC (British Broadcasting Corporation). (2019). Climate change: MSPs approve beefed up emissions target. *BBC News*. https://www.bbc.co.uk/news/uk-scotland-49819905 (Accessed on: 02/12/2019)

BEIS (UK Department for Business, Energy and Industrial Strategy). (2019). News story: UK becomes first major economy to pass net zero emissions into law. https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law (Accessed on: 02/12/2019)

Berkhout, F., Marcotullio, P., and Hanaoka, T. (2012). Understanding energy transitions. *Sustainability Science*, 7(2), 109-111. https://doi.org/10.1007/s11625-012-0173-5

Bhattacherjee, A. (2012). *Social Science Research: Principles, Methods, and Practices*. Textbooks Collection. 3. http://scholarcommons.usf.edu/oa_textbooks/3 (Accessed on: 02/12/2019)

Bolton, P. (2008). Renewable Energy Statistics. https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN03217 (Accessed on: 02/12/2019)

Boudet, H. S. (2019). Public perceptions of and responses to new energy technologies. *Nature Energy*, 4(6), 446-455. https://doi.org/10.1038/s41560-019-0399-x

Bryman, A. (2012). *Social Research Methods 4th edition*. Oxford: Oxford University Press.

Burningham, K. (2000). Using the language of NIMBY: A topic for research, not an activity for researchers. *Local Environment*, 5(1), 55–67. doi.org/10.1080/135498300113264

Clark, P. (2013). UK solar power rush sparks local protest. *Financial Times*. https://www.ft.com/content/0bc15800-043d-11e3-a8d6-00144feab7de?mhq5j=e5 (Accessed on: 02/12/19)

Devine-wright, P. (2009). Rethinking NIMBYism: The Role of Place Attachment and Place Identity in Explaining Place-protective Action. *Journal of Community and Applied Social Pyschology*, 19(6), 426–441.

https://doi.org/10.1002/casp.1004

Dobson, P. J. (2002). Critical realism and information systems research: why bother with philosophy. *Information Research*, *7*(2). http://informationr.net/ir/7-2/paper124.html

DUKES (Digest of UK Energy Statistics). (2020). Chapter 6: Renewable sources of energy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905060/DUKES_2020_MASTER.pdf (Accessed on 11/08/20)

EEA (European Environment Agency). (2019). Share of renewable energy in gross final energy consumption. https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-3 (Accessed on: 02/12/19)

Evensen, D., Demski, C., Becker, S., and Pidgeon, N. (2018). The relationship between justice and acceptance of energy transition costs in the UK. *Applied Energy*, 222, 451–459. https://doi.org/10.1016/j.apenergy.2018.03.165

Fast, S. (2013). Social Acceptance of Renewable Energy: Trends, Concepts, and Geographies. *Geography Compass*, 7(12), 853–866. https://doi.org/10.1111/gec3.12086

Gaede, J., and Rowlands, I. H. (2018). Visualizing social acceptance research: A bibliometric review of the social acceptance literature for energy technology and fuels. *Energy Research and Social Science*, 40, 142–158. https://doi.org/10.1016/J.ERSS.2017.12.006

George, A. L. and Bennet, A. (2004). *Case Studies and Theory Development in the Social Sciences*. Cambridge, Massachusetts; London, England: MIT Press.

Grubb, M., and Newbery, D. (2018). UK Electricity Market Reform and the Energy Transition: Emerging Lessons. *MIT Centre for Energy and Environmental Policy Research, Working Paper Series*. https://doi.org/10.17863/CAM.24680

Haggett, C. and Toke, D. (2006). Crossing the great divide-using multi-method analysis to understand opposition to windfarms. *Public Administration*, 84(1), 103–120. https://doi.org/10.1111/j.0033-3298.2006.00495.x

Healy, M., and Perry, C. (2000). Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative Market Research*, 3(3), 118-126. https://doi.org/10.1108/13522750010333861

IEA (International Energy Agency). (2019). *World Energy Outlook 2019*. OECD Publishing, Paris. https://doi.org/10.1787/caf32f3b-en (Accessed on 02/12/2019)

IPCC (Intergovernmental Panel on Climate Change). (2011). *Summary for Policymakers*. In: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (Intergovernmental Panel on Climate Change). (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], Cambridge University Press, Cambridge, UK and New York, NY, USA.

Krauss, S. E. (2005). Research Paradigms and Meaning Making: A Primer. *The Qualitative Report*, 10(4), 758-770. http://nsuworks.nova.edu/tqr/vol10/iss4/7

Lockwood, M. (2013). The political sustainability of climate policy: The case of the UK Climate Change Act. *Global Environmental Change*, 23(5), 1339-1348.

MacArthur, J. L. (2016). Challenging public engagement: participation, deliberation and power in renewable energy policy. *Journal of Environmental Studies and Sciences*, 6(3), 631–640. https://doi.org/10.1007/s13412-015-0328-7

McCollum, D. L., Zhou, W., Bertram, C., De Boer, H. S., Bosetti, V., Busch, S. and Fricko, O. (2018). Energy investment needs for fulfilling the Paris Agreement and achieving the Sustainable Development Goals. *Nature Energy*, 3(7), 589. doi:10.1038/s41560-018-0179-z

Merriam, S.B., Johnson-Bailey, J., Lee, M.Y., Kee, Y., Ntseane, G. and Muhamad, M., 2001. Power and positionality: Negotiating insider/outsider status within and across cultures. *International Journal of Lifelong Education*, *20*(5),405-416. https://doi.org/10.1080/02601370120490

Pidgeon, N., Demski, C., Butler, C., Parkhill, K., and Spence, A. (2014). Creating a national citizen engagement process for energy policy. *Proceedings of the National Academy of Sciences of the United States of America*, 111(4), 13606–13613. https://doi.org/10.1073/pnas.1317512111

Rand, J., and Hoen, B. (2017). Thirty years of North American wind energy acceptance research: What have we learned? *Energy Research and Social Science*, 29, 135–148. https://doi.org/10.1016/j.erss.2017.05.019

UK Parliament. (2016). 2020 renewable heat and transport targets. https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/173/17302.htm (Accessed on 02/12/2019)

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5), 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

Welsh Government, 2019. Wales accepts Committee on Climate Change 95% emission reduction target. https://gov.wales/wales-accepts-committee-climate-change-95-emissions-reduction-target (Accessed on 02/12/2019)

Wüstenhagen, R., Wolsink, M., and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. https://doi.org/10.1016/J.ENPOL.2006.12.001

Yin, R. K. (2009). *Case study research: Design and methods (4th Ed.)*. Thousand Oaks, CA: Sage.

2. Literature review

The research presented in this thesis sits at the intersection of several bodies of academic literature. There is a substantial body of work in the environmental social sciences on public acceptance of RE and how it can be conceptualised and explained, which is introduced in Section 2.1. This body of work intersects with and is informed by multiple other literatures including energy geography, energy justice and environmental psychology. These literatures are introduced respectively in Sections 2.2, 2.3 and 2.4, focusing on how they relate to the central research topic of public acceptance of RE. Less commonly acknowledged are the overlaps between the ecosystem services (ES) literature and public acceptance of RE (Holland *et al.*, 2016). This literature is introduced in Section 2.5, demonstrating how it provides a novel lens through which to explore public acceptance of RE. Collectively, these literatures constitute the conceptual framework of the thesis, which guides the research and informs the concepts utilised therein (Figure 4). They were selected as they help to holistically think through the multi-factorial drivers of public acceptance of RE. Section 2.6 provides an overview of governance of energy transitions literature which frames the wider context of the thesis' applied, policy-oriented contributions.

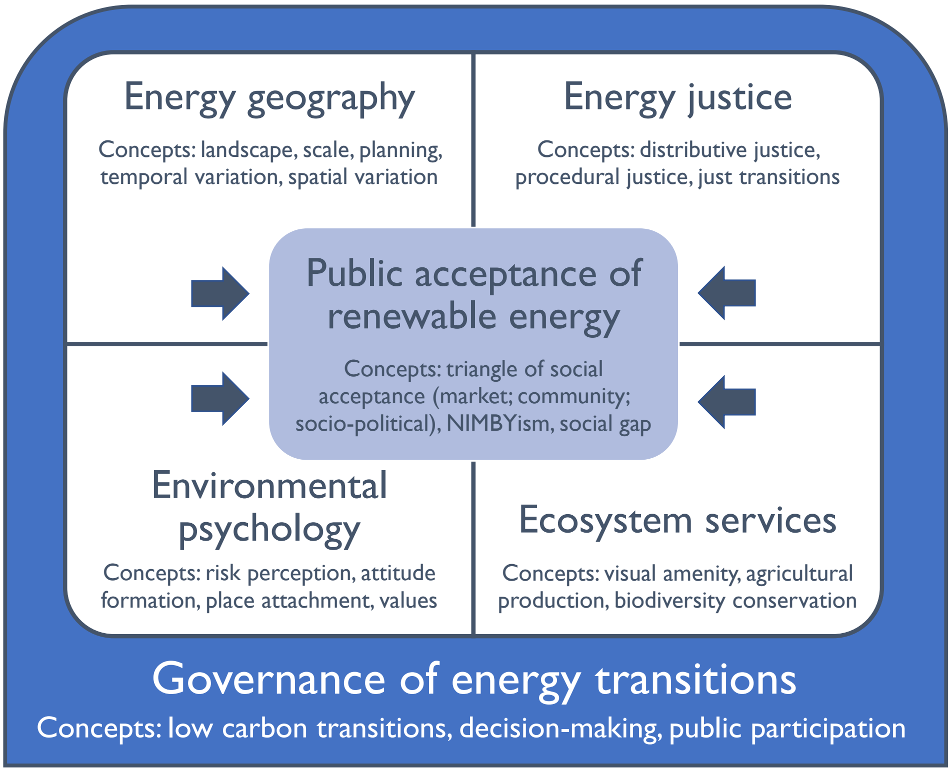

Figure 4. Conceptual framework of the thesis

2.1 Public acceptance of renewable energy

Public acceptance literature approaches the topic of energy in several different ways. Some studies focus on public acceptance of specific instances of built energy infrastructure such as an offshore wind farm (Ellis *et al*., 2007), a biomass gasifier (Upham and Shackley, 2007) or a high voltage power line (Devine-Wright, 2013). Other studies consider public acceptance of the *fuel* rather than the associated built infrastructure. For example, Dockerty *et al*. (2012) investigate public opinion on energy crops which act as a feedstock to biomass power stations, which can be thought of as an example of 'green infrastructure'. Other studies explore public responses to a *method* of fuel production rather than the fuel itself, such as community opposition to hydraulic fracturing infrastructure for shale gas (e.g. Carter and Fusco, 2017). What each of these examples have in common is that they refer to concrete, localised instances of public acceptance. This type of public acceptance is described in the literature as 'community acceptance', referring to the reaction(s) of affected local communities or wider 'communities of relevance' to energy *infrastructure*, broadly defined (Batel, 2017). This draws upon the influential 'triangle of social acceptance' framework by Wüstenhagen *et al*. (2007) (Figure 5).

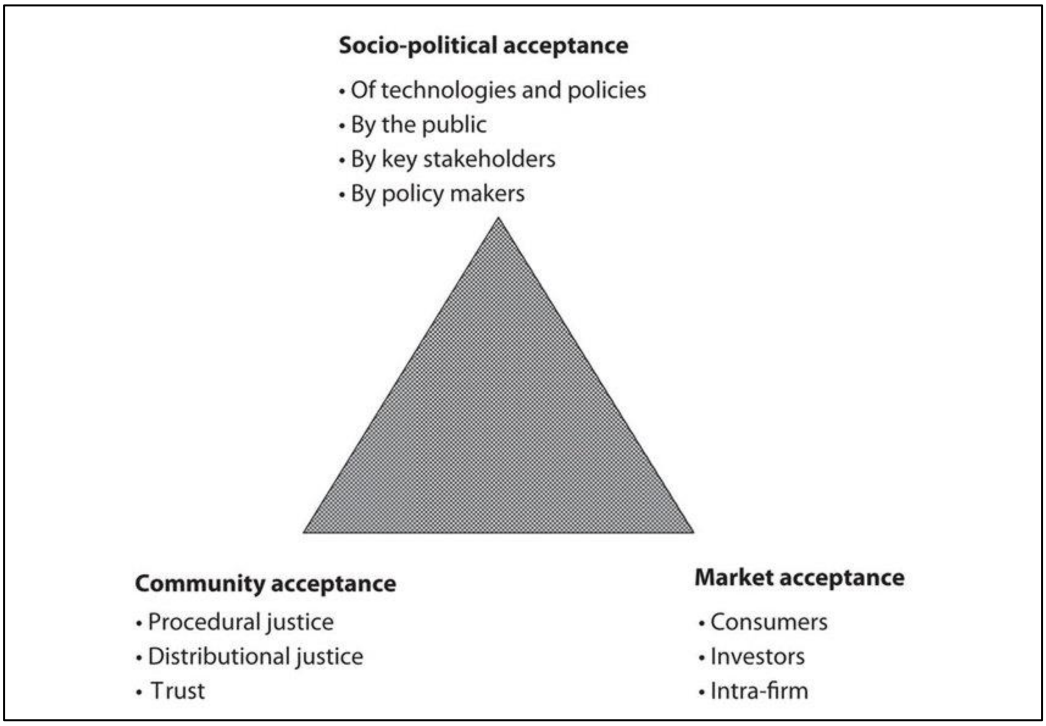

Figure 5. Triangle of social acceptance framework (Wüstenhagen *et al*., 2007)

Other studies take a more abstract, generalised approach by focusing on public acceptance of an energy technology or energy policy, rather than infrastructure. These studies often focus on the national scale rather than the localised instances of acceptance. For example, Liu *et al*. (2017) explore factors influencing public support for coal-fired power plants in China, and Goldfarb *et al*. (2016) investigate how proximity to coal plants in the United States (US) affects public support for the Production Tax Credit policy. Public acceptance of a technology or policy is described by Wüstenhagen *et al*. (2007) as 'socio-political acceptance', referring to general attitudes or opinions. Importantly, it is not exclusive to the public; policymakers and other stakeholders can also hold (or withhold) socio-political acceptance. For instance, if a leading political party objects to a particular type of energy they could prevent institutional arrangements which support it. This is why scholars such as Maarten Wolsink (2019) emphasise the distinction between *public* and *social* acceptance: the latter including all actors that shape the uptake of what he describes as 'energy innovation'. Wolsink argues that the object of acceptance is always innovation; however, this thesis uses the terms 'infrastructure' and 'technology/source' to be clear about the object of acceptance being referred to, whilst recognising these are embedded in broader processes of energy innovation. This thesis focuses on the public as a key stakeholder in social acceptance processes.

The third point on the 'triangle of social acceptance' is market acceptance. This refers to market adoption of an energy innovation by consumers or investors. For example, the uptake of rooftop solar PV by households is an illustration of market acceptance by consumers, as is switching to a RE tariff (Wüstenhagen *et al*., 2007). This type of acceptance conceptualises the public in a different way to community and socio-political acceptance, as it positions individuals as consumers rather than citizens. van Rijnsoever *et al*. (2015) describe these characterisations as being based on whether individuals have a direct or indirect role within the innovation process. They argue that citizens play a fairly indirect role by voicing their opinions or acting in ways that support or resist a technology or infrastructure, whilst consumers play a more direct role by adopting or using energy innovations. This thesis focuses on the public in their role as citizens. Given this, it concentrates on two measures of public acceptance: socio-political (general attitudes to RE sources) and community (local responses to RE infrastructure). Market acceptance is beyond the scope of the thesis as it requires a different set of methods to measure it, it conceptualises the public in a very different way, and is not directly relevant to the research questions.

Because of these different understandings of and approaches to public acceptance, it is important for studies to be clear about what type of acceptance is being measured, and to be specific about how public acceptance is being defined. This thesis follows the definition of public acceptance provided by Upham *et al*. (2015) as 'a favourable or positive response (including intention, behaviour and – where appropriate – use) relating to a proposed or in situ technology or socio-technical system, by members of a given social unit (country or region, community or town, household or organization)' (p. 103). Importantly, it does not regard 'acceptance' and 'non-acceptance' as binary positions: it conceptualises acceptance as a scale covering a spectrum of positions, from active support to passive tolerance to active opposition. As Wolsink argues, it covers 'all dynamic positions and actions – taking initiatives, early adoption, support, resistance, opposition, apathy, tolerance, uncertainty, indifference' (2018, p. 291). Some studies use simplified categories such as 'for' and 'against' to broadly categorise these positions and actions (e.g. Baxter *et al*., 2013), which can remove important nuance in how people feel towards a particular energy issue. This thesis avoids this simplification as much as possible, though sometimes uses these categories as shorthand for where people are positioned along the scale of acceptance, whilst recognising its manifold nature.

Importantly, as noted in Section 1.2, NIMBYism has traditionally been the dominant way of understanding public acceptance of energy infrastructure (van der Horst, 2007). This refers to general support for a technology in principle (i.e. socio-political acceptance), yet simultaneous opposition to the implementation of that type of infrastructure at a local level when it will directly affect one's own neighbourhood (i.e. community acceptance). This divergence between dimensions of acceptance is often described as the 'social gap' (Bell *et al.*, 2005). However, many scholars reject the use of NIMBY framing in relation to public acceptance issues as it overlooks the nuances of siting conflicts (Wolsink, 2006). Furthermore, there is limited evidence that local responses to energy infrastructure are in fact characterised by NIMBYism (Haggett, 2011). Instead, research suggests that communities tend to be motivated by emotional attachment to place (Devine-Wright, 2009), genuine concerns around the development based on local knowledge (Aitken, 2010), or issues of trust and transparency in the developer and involvement in decision-making processes (Gross, 2007). These topics are covered in more details Sections 2.2 – 2.5, bringing together insights from different disciplines to provide a more holistic understanding.

2.2. Energy geography

Energy plays a central role in socio-spatial relations, from geopolitical relationships to shaping mobility patterns and lifestyles. As such, 'the study of energy is increasingly recognised as being at the heart of the geographic tradition' (Calvert, 2015, p. 106). It has been described by geographer Kirby Calvert as a 'fertile academic borderland' (2015) encompassing both human and physical geography as well as numerous other disciplinary and sub-disciplinary approaches (Figure 6). Gavin Bridge *et al*. (2013) argue that energy transitions are inherently geographical processes and must be examined as such. This thesis draws upon energy geography literature to explore the spatial aspects of public acceptance of RE in GB, as well as using concepts from the geographic discipline to help describe, explain and understand public acceptance of RE as a socio-spatial phenomenon.

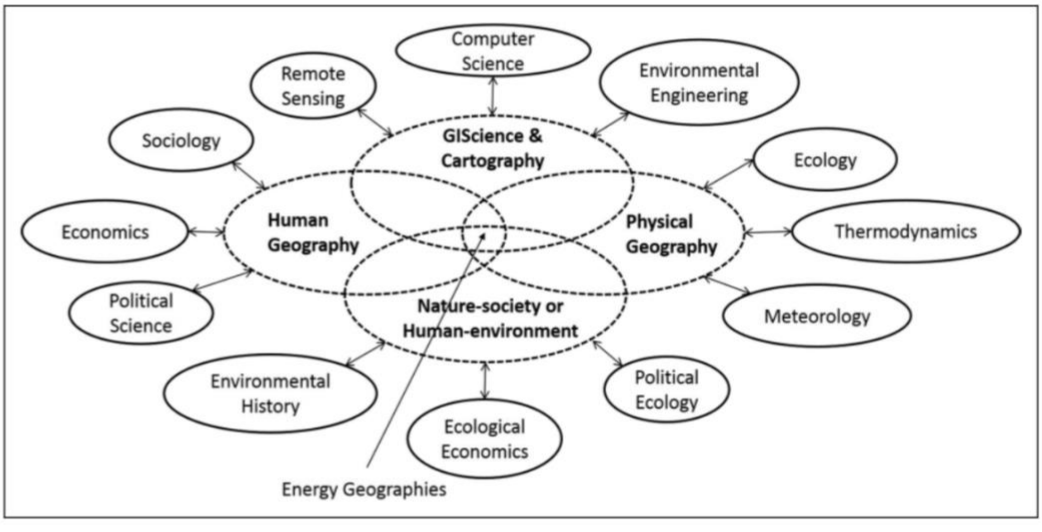

Figure 6. Subfields and 'borderlands' (overlapping subfields) of energy geography and connections with other academic disciplines (Calvert, 2015)

Of relevance to the topic of public acceptance of RE is the geographical concept of landscape. The term 'landscape' has multiple and contested definitions, depending on the academic discipline or applied context in which it is used. Bridge *et al*. describe it as 'the assemblage of natural and cultural features across a broad space' (2013, p. 335). The European Landscape Convention defines it as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe, 2000). These definitions are important as they highlight the role of people, culture and perceptions in creating landscapes, rather than conceptualising landscape as an objective physical entity.

Bridge *et al*. observe that 'the transition towards a low carbon economy will require the reappraisal of the form, function and value of some contemporary and familiar landscapes' (2013, p. 335). This includes carbon-producing landscapes (e.g. sites of energy generation, industrial landscapes) and carbon-storing landscapes (e.g. marshes, uplands). As a result, they argue that 'for many people, "low carbon energy transition" is experienced as the transformation of landscape' (2013, p. 335), bringing this issue to the forefront of public acceptance of RE. One of the reasons why RE sources have such profound landscape implications is because they are low density and much more distributed than conventional energy sources, meaning they require a larger amount of land than the current fossil-fuel based energy system (Apostol *et al*., 2016). Some RE technologies have unique visual impacts, such as the dynamic aspect of wind turbines given that the blades are rotating, and the issue of glare associated with solar technologies (Apostol *et al*., 2016). Whilst offshore technologies such as wind, wave and tidal are often posited as a solution to landscape impacts, these too can have visual impacts and give rise to concerns around 'seascapes', particularly as the optimal sites for offshore energy are often close to the shore and thus highly visible (Bailey *et al*., 2011; Firestone *et al*., 2018).

For some geographical scholars (e.g. those that take an environmental planning perspective), solving the landscape 'problem' is therefore fundamental to managing and delivering a publicly acceptable RE transition. For instance, Apostol *et al*. (2016) argue that there is no precedent in scenic resource management for the landscape change incurred by RE, and that new approaches to Landscape and Visual Impact Assessment (LVIA) and spatial planning are needed to avoid 'turning highly valued scenic landscapes into industrial scale energy harvest landscapes' (p. 8). This perspective implies a belief in planning and techno-managerial solutions to fix this issue. However, other scholars argue for a shift in perspective towards RE landscapes given the urgency of climate change and the imperative of sustainable development. For instance, Selman (2010) demonstrates how energy production and consumption patterns have fundamentally shaped the British landscape and contends that there is the potential for society to develop a taste for emerging RE landscapes if the underlying narratives behind them are socially endorsed. He writes: 'Landscape changes often provoke controversy, and yet may produce outcomes which become accepted and valued after a period of time', (p. 169). This reframes the landscape 'problem' as a more socially constructed issue, rather than one which can be solved with technical solutions or through better spatial planning.

A similar perspective is taken by geographer Martin J. Pasqualetti, who has written extensively on energy landscapes, particularly in the US. He suggests that a key explanation for opposition to RE developments is that many people have become accustomed to not seeing, or even knowing, where their energy supply comes from (Pasqualetti, 2000). This is a result of the dispersed fuel chains associated with conventional energy production, in which fossil fuels are extracted in a different location to where they are combusted, thereby spatially diluting the impacts of energy generation. He argues this has buffered consumers from the environmental costs of their energy usage and led to an 'out of sight, out of mind' mentality (Pasqualetti, 2000). RE technologies, by contrast, are characterised by spatial inflexibility in that facilities must be sited where the resource is available, leading to a concentration of impacts and 'reminding us afresh of the responsibilities we have for the energy we use' (Pasqualetti, 2000, p. 382). Like Selman, Pasqualetti indicates that there will likely need to be adjustments to people's expectations of landscapes and possibly seascapes if RE is to become an accepted mode of energy generation. This thesis explores the role of landscape, aesthetics and visual impacts in shaping public responses to RE, alongside a range of other factors and influences.

Another important geographical concept utilised in this thesis is scale. Gibson *et al*. (2000) define scale as 'the spatial, temporal, quantitative or analytical dimensions used by scientists to measure and study objects and processes' (p. 219). The spatial scale at which public acceptance is measured has an important effect on how it is understood. For instance, high levels of support for wind energy at a national scale measured by opinion polls are often very different to acceptance at a local scale, measured by community reactions to actual wind projects i.e. what is commonly known as the 'social gap' (Bell *et al*., 2005). Temporal scale is also relevant as research indicates that public acceptance of RE not static but changes over time (e.g. Vanhulle *et al*., 2010; Wilson and Dyke, 2016; Rand and Hoen, 2017), though it is unclear whether this is due to familiarity or something else. The thesis thus takes account of spatial and temporal scales when exploring public acceptance of RE, with the understanding that this phenomenon is likely to vary across time and space.

2.3. Energy justice

The transition to a low carbon society provokes a range of considerations around justice, fairness and well-being (Büchs *et al*., 2011). As argued by Klinksy *et al*. (2016): 'Justice, and its flipside injustice, are central to the intersection of climate change and human well-being' (p. 172). Multiple justice theories have been developed in relation to low carbon transitions, including energy justice, environmental justice, climate justice and just transition theory (Jenkins, 2018). As indicated in the original 'triangle of social acceptance' framework, justice considerations have long been central to work on public acceptance of RE. This framework highlights 'distributive' and 'procedural' justice as core components of community acceptance. Distributive justice refers to the fair distribution of costs and benefits across society, regardless of sociodemographic characteristics such as race and income (Walker, 2009). Procedural justice refers to equal participation in decision-making for all affected stakeholders, for example consultation of local residents and businesses in areas where RE projects are proposed (Sovacool *et al*., 2016). Some justice scholars additionally distinguish between procedural and recognition justice (e.g. Fraser, 1997; Schlosberg, 2007). Whilst similar concepts, recognition justice is differentiated by its focus on *who* is recognised as an important stakeholder, recognising that some social groups are disadvantaged within society and formal participation processes.

This thesis engages with theories of justice to understand how perceptions of justice shape public acceptance of RE. It primarily draws upon energy justice theory, which considers distributive, procedural and recognition justice in relation to issues across the energy lifecycle, from cradle to grave (Heffron and McCauley, 2014). Energy justice shares the same three 'pillars' (i.e. distributive, procedural and recognition) as other prominent justice theories (Jenkins, 2018). This has led to calls by some academics to combine energy, environmental and climate justice into a unified 'just transition' concept (Heffron and McCauley, 2018). However, this is not necessarily straightforward as each of these justice theories make different claims about what is 'just' and focus on different geographical scales (Fraser, 2008). As highlighted by scholar Matthew Cotton, there are strong overlaps between energy justice and environmental justice particularly when it comes to infrastructure siting (Cotton, 2018). This thesis therefore applies energy justice theory with the understanding that it cannot necessarily be neatly integrated with other approaches to justice but that it is embedded within and indebted to longstanding traditions of environmental justice, which in turn also has roots within social justice theory (Scholsberg, 2007).

Whilst there are many diverse claims about justice in relation to energy transitions, and multiple 'objects' of justice can be focused upon, an important consideration is the distribution of employment. Indeed, the concept of a 'just transition' originally emerged from the trade union movement to highlight the need to protect jobs and livelihoods of those affected by the transition, such as communities reliant on fossil fuel industries for employment (Morena *et al.*, 2019). The concept has since been adopted by multiple groups and expanded to encompass concerns such as fair adaptation to climate impacts (Stevis and Felli, 2016), improving human well-being in terms of income, education and health (Swilling *et al.*, 2016) and reducing inequalities in terms of exposure to localised degradation (Newell and Mulvaney, 2013). The term 'just transition' is therefore often understood in different ways by diverse stakeholder groups. This thesis seeks to capture this diverse and pluralistic understanding of justice whilst also contributing empirical evidence where possible.

The first empirical chapter (Chapter 3) applies energy justice theory to community acceptance of onshore wind and solar farms in GB, raising questions about whether RE infrastructure can be understood as a distributional injustice in the way that other types of development traditionally have been. The second empirical chapter (Chapter 4) touches upon how perceptions of distributive justice may influence public attitudes to RE across GB. The third empirical chapter (Chapter 5) considers how justice concerns manifest themselves in the specific instance of the siting conflict regarding Cleve Hill Solar Park. A distinctly geographical perspective towards justice is taken throughout the thesis, acknowledging the multiple spatial dimensions of justice and responding to calls from scholars to apply geographical thinking to a range of justice issues (Bouzarovski and Simcock, 2017; Walker, 2009).

2.4. Environmental psychology

Another important body of literature for public acceptance of RE is environmental psychology (Whitmarsh *et al.*, 2011). Indeed, the origins of public acceptance research lie in risk perception scholarship (a sub-field of psychology), triggered by widespread contestation over nuclear power (Wolsink, 2018). Risk perception studies are concerned with how people make judgements about potentially hazardous activities or technologies. This has a strong link with whether the public accepts new technologies, such as RE. As risk scholar Paul Slovic (1987) describes:

> '*Results from studies of the perception of risk have been used to explain and forecast acceptance and opposition for specific technologies [...] Research shows that people judge the benefits from nuclear power to be quite small and the risks to be unacceptably great [...] Attempts to "educate" or reassure the public and bring their perceptions in line with those of industry experts appear unlikely to succeed.'* (p. 284-5)

Although the focus of this thesis is public acceptance of RE rather than nuclear power, lessons can be learnt from this body of research on how people form preferences and make judgements about what types of energy are acceptable. For instance, as Slovic refers to, the assumption that providing people with information will make them 'accept' new technologies (i.e. the information-deficit model) has been investigated in the context of public acceptance of RE (e.g. Bidwell, 2016), finding that information may have an influence but is only one of a variety of factors.

Attitude theory from social psychology, which is concerned with how people make evaluations, is another important influence on studies of public acceptance of RE. An attitude can be defined as 'a favourable or unfavourable evaluative reaction toward something or someone, exhibited in one's beliefs, feelings, or intended behaviour' (Myers, 2012, p. 36). Attitudes are generally considered to have three dimensions: cognitive, relating to our knowledge, thoughts and beliefs; affective, relating to our feelings and emotions; and behavioural, relating to how we act (Whitmarsh *et al.*, 2011). In some cases, there can be a mismatch between these aspects. For example, a belief that new RE infrastructure is required does not necessarily lead to behaviour which aligns this belief (Waldo, 2012). Where relevant, this thesis considers the role of attitudes in shaping people's acceptance of RE, including how this interacts with other variables such as sociodemographic characteristics, which have also been shown to be an important influence on public acceptance of RE (Bishop and Miller, 2007). However, it is alert to the fact that a positive attitude is only one aspect of acceptance and may not align with behaviour.

Another key psychological concept which has informed public acceptance of RE research is place attachment. This refers to the emotional bond between people and place, often the place in which they live, though sometimes other places such as holiday destinations or places regarded as special in some way (Gurney *et al*., 2017). Public acceptance scholar Patrick Devine-Wright has explored this in-depth in relation to public reactions to RE projects in the UK. He argues that NIMBYism should be reconceived as 'place-protective action' that arises when RE projects disrupt emotional bonds and threaten place-related identities (Devine-Wright, 2009). His research has found place-attachment to be an important predictor of acceptance in a range of contexts, including an onshore wind farm in Wales (Devine-Wright and Howes, 2010), a tidal energy project in Northern Ireland (Devine-Wright,

2011) and a powerline in South West England (Devine-Wright, 2013). Similarly, Vorkinn and Riese (2001) identify place-attachment as a significant predictor of acceptance for a proposed hydropower project in Norway. Interestingly however, place attachment was not identified as an important predictor for another wind farm in Wales (Devine-Wright and Howes, 2010) which was proposed in a more industrialised area that was not perceived as 'natural' by residents. This indicates the linkages between landscape, place attachment and public acceptance of RE.

Other psychological research in the UK has focused on the role of values in shaping public acceptance of RE. For example, Parkhill *et al*. (2013) conducted a synthesis analysis of qualitative and quantitative datasets to identify the core values underlying public perspectives on energy transitions. They found that public preferences for energy technologies were underpinned by *general* positions that underlie *particular* concerns, and these general positions (or 'values') are heavily drawn upon when forming preferences. To illustrate, strong public preferences for solar energy were found to be underpinned by perceptions that it is 'renewable', 'fair', 'just', and 'clean'. They therefore argue that *why* people favour particular technologies provides more meaningful insights than *which* technology they favour, because if solar energy were to be deployed in a way that was inconsistent with these underlying beliefs it would no longer enjoy the same level of public support.

This links closely to research on the role of political values in public acceptance of RE. For example, Bidwell (2013) finds that public opposition to wind energy is linked to traditional values as opposed to altruistic values, therefore arguing that it is 'fuelled by conservativism' (p. 197) rather than by NIMBYism. Other research has identified a similarly important role for values in motivating low carbon behaviour, such as reducing air travel (Büchs, 2017). Butler *et al*. (2015) argue that dominant UK policy framings of energy system change substantially diverge from framings that resonate with public values. They suggest that inclusion of framings within energy policy that are in line with people's psychological and political values may help to improve overall public acceptance of RE transitions. Where possible, this thesis therefore also considers the role of values in shaping public acceptance of RE.

2.5. Ecosystem services

Whilst RE is a critical part of the response to climate change, the development of new RE infrastructure inevitably entails impacts on the natural environment and the range of ES it provides (Holland *et al.*, 2016). This in turn may influence public acceptance of RE, for example as a result of a loss of visual amenity provided by scenic landscapes, though this has been under-explored in the literature to date. ES have become an increasingly common feature of environmental policy and practice in recent years, as well as a key frame within academic research. ES are defined in the Millennium Ecosystem Assessment as 'the benefits people obtain from ecosystems [including] provisioning, regulating, cultural and supporting services' (Duraiappah *et al.*, 2005, p. V). The ecosystems which provide these services are commonly described as 'natural capital', applying the financial characterisation of capital as 'stocks' which yield 'flows' of services (TEEB, 2010). One of the central purposes of ES research is to enable better integration of the economic value of the natural environment into decision-making, given that this value is not otherwise captured by classical economic approaches. However, the ES framework can also be applied as a conceptual approach to understanding human-nature relations and a means to articulate the things that people value about the natural environment.

This thesis uses the ES concept to articulate how the impacts of RE on the natural environment may shape public acceptance, alongside other determinants. RE sources affect ES in different ways. This includes provisioning services such as the availability of fresh water (Holland *et al.*, 2015) and land for food production (Lovett *et al.*, 2014), regulating and supporting services such as biodiversity (Gove *et al.*, 2016), and cultural services such as the visual amenity of natural landscapes (Apostol *et al.*, 2016). Impacts can be either positive or negative, or sometimes a mixture of both. For example, using agricultural land for solar farms may negatively impact upon primary production of food, but may boost soil quality by reducing the use of chemicals and fertilisers on the land. If the same land were to be used to grow bioenergy crops, this may have less of an impact on visual amenity but require increased amounts of fresh water. Holland *et al.* (2016) suggest that integrating ES into energy planning processes could help to improve public acceptability of RE by illuminating trade-offs that different stakeholders are willing to accept and the environmental benefits that they consider to be the most (and least) important.

As discussed in Sections 2.2 and 2.4, landscape and place attachment are identified in the existing literature as key drivers of public acceptance of RE. Visual amenity provided by valued and/or scenic landscapes is therefore a particularly important ES issue to consider in this thesis. However, it is important to be aware of how ES values and preferences vary between social groups. For example, Ladenburg and Dubgaard (2009) found that preferences for reducing the visual disamenities from offshore windfarms varied between frequent and less frequent coastal zone users. Using a choice experiment, whereby participants are asked to state what they would be willing to pay for different options, they found that frequent users (e.g. residents, visitors, anglers and recreational boaters) were willing to pay approximately twice as much as non-frequent users to have future offshore windfarms sited further away from the coast. This highlights that how ES shape public acceptance of RE is highly context specific and is likely to vary between demographic/user groups who interact with the natural environment in different ways and value differing aspects of it.

Additionally, the role of ES in public acceptance is likely to vary between RE technologies. For instance, several studies find that perceptions of visual impact are the strongest single influence on individuals' attitudes towards wind energy (Pasqualetti *et al*., 2002; Warren *et al*., 2005; Wolsink, 2000). Whilst visual impacts of wind energy tend to be thought of as negative, some studies have in fact found them to be positively welcomed. For instance, Ellis *et al*. (2007) found that certain local residents in Northern Ireland responded very positively to a proposed offshore wind farm partly because of their visual impact, with one research participant commenting: '*I am all for windmills. I think it gives movement to the land and sea*' (p. 534). However, there is less research into how impacts on ES such as visual amenity shape attitudes towards other types of RE. For example, little research has been done on the role of visual amenity in public acceptance of large-scale solar farms (Smardon and Pasqualetti, 2016). This therefore represents a gap in the literature which this thesis contributes towards by bringing ES into dialogue with public acceptance of RE literature. In doing so, this thesis seeks to demonstrate how ES thinking can provide a novel lens through which to explore public acceptance of RE.

2.6. Governance of energy transitions

As outlined in the previous sections (Sections 2.1 - 2.5), there are a wide range of studies from multiple disciplines analysing public acceptance of RE and how this can be conceptualised and explained. However, a relatively under-explored aspect of this research topic is how public acceptance (or lack of) shapes the broader dynamics of low carbon transitions. There is an implicit assumption in much academic literature on this topic that a lack of public acceptance acts as a barrier to the deployment of RE and thus broader climate mitigation (e.g. Kern and Rogge, 2016). However, this assumes that public acceptance plays a clearly defined role in energy governance that is not always articulated. There has been limited academic analysis of the ways in which public acceptance actually influences RE decision-making and how these dynamics shape the ways in which RE transitions play out. This thesis aims to contribute to this gap by investigating and characterising the relationships that exist between public acceptance and decision-making at both local and national levels in GB. This section of the literature review therefore situates the thesis topic within wider debates about the governance of low carbon energy transitions.

As noted by Newell and Mulvaney (2013), 'transition' has become the dominant frame in policy and politics to describe plans for shifting to a low carbon future. This originates from the academic literature on 'socio-technical transitions' (Geels 2005; Geels and Schot 2007) which investigates how deep structural changes in systems such as energy can be reconfigured towards a sustainable society and economy. This body of literature has developed over the last twenty or so years in correspondence with society's increasing knowledge of climate change and environmental limits. A central concept in the literature is 'socio-technical systems', which emphasises that technologies are embedded within social and economic systems (Smith *et al.*, 2005). This perspective highlights that changes to the energy system, for example shifting from a fossil fuel driven system to RE, is not simply a matter of changing technology but transforming the entire social, economic, environmental and technical systems that energy production, transmission and consumption are embedded within.

Another key focus of the transitions literature relates to the governance of these socio-technical systems, known as 'transitions management'. This examines both the destabilisation of the existing regime and the fostering of niche-level innovation (Gillard *et al.*, 2016; Turnheim and Geels, 2012). A key factor in relation to regime change is the 'diffusion of innovations' (Rogers, 2010), which considers how and why innovations are taken up by a population, with an emphasis on peer-to-peer communication and networks. This perspective is helpful in terms of analysing market acceptance but overlooks the ways in which community and socio-political acceptance – aspects of public acceptance that are harder to 'manage' – may shape how transitions unfold. As such, there is an increasing recognition of the need to account for the role of politics and social dynamics in the transitions literature (e.g. Meadowcroft, 2009; Kuzemko, 2013). There is also an increasing focus on the need to ensure proposed transitions are 'just', going beyond the more apolitical and managerial origins of the transitions concept (Goldthau and Sovacool 2012).

Some recent studies have applied this more politicised perspective to energy transitions, thereby better conceptualising the public as part of the energy socio-technical system. For example, Sovacool (2017) analyses political contestation as a barrier to the low carbon transition, focusing on the Nordic countries as case studies. He identifies the 'risk of an unstable and unpredictable policy environment; declining rates of social acceptability for decentralized energy systems and electric transmission lines and cables; and a growing intolerance for carbon and energy targets as key areas of political contestation which could have implications for these countries' transitions (2017, p. 577). The paper highlights that moving to a low carbon economy will create its own set of winners and losers, and that public and political support can change drastically over a very short period of time. Nevertheless, it does not explore in detail the decision-making processes and governance mechanisms through which this might have knock-on effects on the wider low carbon transition.

Similarly, Kern and Rogge (2016) present an optimistic vision of the low carbon transition based on policy signals such as the UN Paris Agreement and the fact that the low carbon transition is being 'actively governed', as opposed to emergent transitions such as the shift from agrarian to industrial societies. Whilst the authors do acknowledge the need for 'the development of strategies to manage resistance to the decarbonisation of the energy system' (p. 16), their analysis does not deeply engage with what such strategies may look like and how they might be enacted. This thesis seeks to contribute to this gap in the transitions literature by exploring how public acceptance actually bears influences over RE decision-making in different contexts in GB. In doing so, it produces a better understanding of the ways in which decision-making processes could potentially be improved to facilitate a smooth and rapid low carbon transition that has the full buy-in and support from the public.

2.7. References

Aitken, M. (2010). Why we still don't understand the social aspects of wind power: A critique of key assumptions within the literature. *Energy Policy*. 38(4): 1834–1841. https://doi.org/10.1016/J.ENPOL.2009.11.060

Apostol, D., Palmer, J., Pasqualetti, M., Smardon, R., and Sullivan, R. (2016). *The Renewable Energy Landscape: Preserving Scenic Values in our Sustainable Future*. Abingdon, Oxon; New York, NY: Routledge.

Bailey, I., West, J., and Whitehead, I. (2011). Out of Sight but Not out of Mind? Public Perceptions of Wave Energy. *Journal of Environmental Policy and Planning*, 13(2), 139–157. https://doi.org/10.1080/1523908X.2011.573632

Batel, S. (2017). A critical discussion of research on the social acceptance of renewable energy generation and associated infrastructures and an agenda for the future. *Journal of Environmental Policy and Planning*, 1–14. https://doi.org/10.1080/1523908X.2017.1417120

Baxter, J., Morzaria, R. and Hirsch, R. (2013). A case-control study of support/opposition to wind turbines: Perceptions of health risk, economic benefits, and community conflict. *Energy Policy*, 61, 931-943. https://doi.org/10.1016/j.enpol.2013.06.050

Bell, D., Gray, T., and Haggett, C. (2005). The "social gap" in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, 14(4), 460–477. https://doi.org/10.1080/09644010500175833

Bidwell, D. (2013). The role of values in public beliefs and attitudes towards commercial wind energy. *Energy Policy*, 58, 189–199. https://doi.org/10.1016/j.enpol.2013.03.010

Bidwell, D. (2016). The effects of information on public attitudes toward renewable energy. *Environment and Behavior*, 48(6), 743-768. doi.org/10.1177/0013916514554696

Bishop, I. D., and Miller, D. R. (2007). Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables. *Renewable Energy*, 32, 814–831. https://doi.org/10.1016/j.renene.2006.03.009

Bouzarovski, S., and Simcock, N. (2017). Spatializing energy justice. *Energy Policy*, 107, 640-648. https://doi.org/10.1016/j.enpol.2017.03.064

Bridge, G., Bouzarovski, S., Bradshaw, M., and Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, 53, 331–340. https://doi.org/10.1016/j.enpol.2012.10.066

Büchs, M., Bardsley, N., and Duwe, S. (2011). Who bears the brunt? Distributional effects of climate change mitigation policies. *Critical Social Policy*, 31(2), 285-307. https://doi.org/10.1177/0261018310396036

Büchs, M. (2017). The role of values for voluntary reductions of holiday air travel. *Journal of Sustainable Tourism*, 25(2), 234-250. https://doi.org/10.1080/09669582.2016.1195838

Butler, C., Demski, C., Parkhill, K. A., Spence, A., and Pidgeon, N. F. (2015). Public values for energy system change. *Global Environmental Change*, 34, 59–69. https://doi.org/10.1016/j.gloenvcha.2015.06.014

Calvert, K. (2015). From 'energy geography' to 'energy geographies': Perspectives on a fertile academic borderland. *Progress in Human Geography*, 40(1), 105–125. https://doi.org/10.1177/0309132514566343

Carter, A. V., and Fusco, L. M. (2017). Western Newfoundland's anti-fracking campaign: Exploring the rise of unexpected community mobilization. *Journal of Rural and Community Development*, 12(1), 98-120. https://journals.brandonu.ca/jrcd/article/view/1356/309

Cotton, M. (2018). Environmental Justice as Scalar Parity: Lessons From Nuclear Waste Management. *Social Justice Research*, 31(3), 238-259. https://doi.org/10.1007/s11211-018-0311-z

Council of Europe. (2000). *European Landscape Convention*. European Treaty Series. https://www.coe.int/en/web/landscape (Accessed on: 02/12/2019)

Devine-wright, P. (2009). Rethinking NIMBYism: The Role of Place Attachment and Place Identity in Explaining Place-protective Action. *Journal of Community and Applied Social Pyschology*, 19(6), 426–441. https://doi.org/10.1002/casp.1004

Devine-Wright, P. (2011). Place attachment and public acceptance of renewable energy: A tidal energy case study. *Journal of Environmental Psychology*, 31(4), 336-343. https://doi.org/10.1016/j.jenvp.2011.07.001

Devine-Wright, P., and Howes, Y. (2010). Disruption to place attachment and the protection of restorative environments: A wind energy case study. *Journal of Environmental Psychology*, 30(3), 271–280. https://doi.org/10.1016/j.jenvp.2010.01.008

Devine-Wright, P. (2013). Explaining "NIMBY" Objections to a Power Line: The Role of Personal, Place Attachment and Project-Related Factors. *Environment and Behavior*, 45(6), 761–781. https://doi.org/10.1177/0013916512440435

Dockerty, T., Appleton, K., and Lovett, A. (2012). Public opinion on energy crops in the landscape: considerations for the expansion of renewable energy from biomass. *Journal of Environmental Planning and Management*, 55(9), 1134–1158. https://doi.org/10.1080/09640568.2011.636966

Duraiappah, A. K. *et al*. (2005) Millennium Ecosystem Assessment. *Ecosystems and human well-being: Synthesis*. Island Press, Washington, DC: USA.

Ellis, G., Barry, J., and Robinson, C. (2007). Many ways to say "no", different ways to say "yes": Applying Q-Methodology to understand public acceptance of wind farm proposals. *Journal of Environmental Planning and Management*, 50. https://doi.org/10.1080/09640560701402075

Firestone, J., Bidwell, D., Gardner, M., and Knapp, L. (2018). Wind in the sails or choppy seas?: People-place relations, aesthetics and public support for the United States' first offshore wind project. *Energy Research and Social Science*, 40, 232–243. https://doi.org/10.1016/j.erss.2018.02.017

Fraser, N. (1997). *Justice Interruptus: Critical reflections on the "Postsocialist" Condition*. New York and London: Routledge.

Fraser, N. (2008). *Scales of Justice: Reimagining political space in a globalizing world*. New York: Columbia University Press.

Gibson, C., Ostrom, E. and Ahn, T. K. (2000). The concept of scale and the human dimensions of global change: a survey. *Ecological Economics*, 32, 217–239. https://doi.org/10.1016/S0921-8009(99)00092-0

Goldfarb, J. L., Buessing, M., and Kriner, D. L. (2016). Geographic proximity to coal plants and U.S. public support for extending the Production Tax Credit. *Energy Policy*, 99, 299–307. https://doi.org/10.1016/j.enpol.2016.03.029

Gove, B., Williams, L. J., Beresford, A. E., Roddis, P., Campbell, C., Teuten, E., Bradbury, R. B. (2016). Reconciling Biodiversity Conservation and Widespread Deployment of Renewable Energy Technologies in the UK. *PloS One*, 11(5), e0150956. https://doi.org/10.1371/journal.pone.0150956

Gross, C. (2007). Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance. *Energy Policy*, 35(5): 2727–2736. https://doi/10.1016/j.enpol.2006.12.013

Gurney, G. G., Blythe, J., Adams, H., Adger, W. N., Curnock, M., Faulkner, L., and Marshall, N. A. (2017). Redefining community based on place attachment in a connected world. *Proceedings of the National Academy of Sciences*, 114(38), 10077-10082. https://doi.org/10.1073/pnas.1712125114

Haggett, C. (2011). Understanding public responses to offshore wind power. *Energy Policy*, 39(2): 503–510. https://doi.org/10.1016/j.enpol.2010.10.014

Heffron, R. J., and McCauley, D. (2014). Achieving sustainable supply chains through energy justice. *Applied Energy*, 123. https://doi.org/10.1016/j.apenergy.2013.12.034

Heffron, R. J., and McCauley, D. (2017). The concept of energy justice across the disciplines. *Energy Policy*, 105, 658–667. https://doi.org/10.1016/j.enpol.2017.03.018

Heffron, R. J., and McCauley, D. (2018). What is the 'Just Transition'? *Geoforum*, 88, 74–77. https://doi.org/10.1016/j.geoforum.2017.11.016

Holland, R., Scott, K. A., Flörke, M., Brown, G., Ewers, R. M., Farmer, E., Eigenbrod, F. (2015). Global impacts of energy demand on the freshwater resources of nations. *Proceedings of the National Academy of Sciences of the United States of America*, 112(48), E6707-E6716. https://doi.org/10.1073/pnas.1507701112

Holland, R. A., Scott, K., Hinton, E. D., Austen, M. C., Barrett, J., Beaumont, N., Taylor, G. (2016). Bridging the gap between energy and the environment. *Energy Policy*, 92, 181–189. https://doi.org/10.1016/j.enpol.2016.01.037

Hooper, T., Austen, M. C., Beaumont, N., Heptonstall, P., Holland, R. A., Ketsopoulou, I., Winskel, M. (2018). Do energy scenarios pay sufficient attention to the environment? Lessons from the UK to support improved policy outcomes. *Energy Policy*, 115, 397–408. https://doi.org/10.1016/j.enpol.2018.01.028

Jenkins, K. (2018). Setting energy justice apart from the crowd: Lessons from environmental and climate justice. *Energy Research and Social Science*, 39, 117–121. https://doi.org/10.1016/j.erss.2017.11.015

Jones, C. R., Orr, B. J., and Eiser, J. R. (2011). When is enough, enough? Identifying predictors of capacity estimates for onshore wind-power development in a region of the UK. *Energy Policy*, 39(8), 4563–4577. https://doi.org/10.1016/j.enpol.2011.04.044

Kern, F., and Rogge, K. S. (2016). The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? *Energy Research and Social Science*, 22, 13-17. https://doi.org/10.1016/j.erss.2016.08.016

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., and Bauer, S. (2016). Why equity is fundamental in climate change policy research. *Global Environmental Change*, 44, 170-173. https://doi.org/10.1016/j.gloenvcha.2016.08.002

Ladenburg, J., and Dubgaard, A. (2009). Preferences of coastal zone user groups regarding the siting of offshore wind farms. *Ocean and Coastal Management*, 52(5), 233–242. https://doi.org/10.1016/j.ocecoaman.2009.02.002

Liu, F., Lyu, T., Pan, L., and Wang, F. (2017). Influencing factors of public support for modern coal-fired power plant projects: An empirical study from China. *Energy Policy*, 105, 398–406. https://doi.org/10.1016/j.enpol.2017.03.017

Lovett, A., Sunnenberg, G., and Dockerty, T. (2014). The availability of land for perennial energy crops in Great Britain. *GCB Bioenergy*, 6(2), 99–107. https://doi.org/10.1111/gcbb.12147

Morena, E., Krause, D. and Stevis, D. (2019) *Just Transitions: Social Justice in the Shift Towards a Low-Carbon World.* London: Pluto Press.

Myers, D. G. (2012) *Social Psychology 11th Edition.* New York: McGraw-Hill.

Newell, P. and Mulvaney, D. (2013). The political economy of the 'just transition'. *The Geographical Journal*, *179*(2), 132-140. https://doi.org/10.1111/geoj.12008

Parkhill, K. A., Demski, C., Butler, C., Spence, A. and Pidgeon, N. (2013). Transforming the UK Energy System: Public Values, Attitudes and Acceptability – Synthesis Report. London: UK Energy Research Centre.

Pasqualetti, M. J., Gipe, P., and Righter, R. W. (2002). A landscape of power. In M. J. Pasqualetti, P. Gipe, and R. W. Righter (eds.), *Wind Power in View: Energy Landscapes in a Crowded World*. San Diego: Academic Press.

Pasqualetti, M. J. (2000). Morality, Space, and the Power of Wind-Energy Landscapes. *Geographical Review*, 90(3), 381–394. http://www.jstor.org/stable/3250859

Rand, J., and Hoen, B. (2017). Thirty years of North American wind energy acceptance research: What have we learned? *Energy Research and Social Science*, 29, 135–148. https://doi.org/10.1016/j.erss.2017.05.019

Schlosberg, D. (2007). *Defining Environmental Justice: Theories, Movements, and Nature.* Oxford: Oxford University Press.

Selman, P. (2010). Learning to Love the Landscapes of Carbon-Neutrality. *Landscape Research*, 35(2), 157–171. https://doi.org/10.1080/01426390903560414

Slovic, P. (1987). Perception of risk. *Science*, 236(4799), 280–285. https://doi.org/10.1126/science.3563507

Smardon, R., and Pasqualetti, M. J. (2016). Social Acceptance of Renewable Energy Landscapes. In D. Apostol, J. Palmer, M. Pasqualetti, R. Smardon, and R. Sullivan (Eds.), *The Renewable Energy Landscape: Preserving Scenic Values in our Sustainable Future*. (pp. 108–142). Abingdon, Oxon; New York, NY: Routledge.

Sovacool, B. K., Heffron, R. J., McCauley, D., Goldthau, A., Jones, B. R., Carvalho, A. (2016). Energy decisions reframed as justice and ethical concerns. *Nature Energy*, 1(5), 16024. https://doi.org/10.1038/nenergy.2016.24

Sovacool, B. K. (2017). Contestation, contingency, and justice in the Nordic low-carbon energy transition. *Energy Policy*, 102, 569–582. https://doi.org/10.1016/j.enpol.2016.12.045

Stevis, D., and Felli, R. (2016). Green Transitions, Just Transitions? Broadening and Deepening Justice. *Kurswechsel*, 3, 33-45.

Swilling, M., Musango, J., and Wakeford, J. (2016). Developmental states and sustainability transitions: prospects of a just transition in South Africa. *Journal of Environmental Policy & Planning*, *18*(5), 650-672. https://doi.org/10.1080/1523908X.2015.1107716

TEEB (The Economics of Ecosystems and Biodiversity). (2010). *Mainstreaming the economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB*. https://portals.iucn.org/library/node/9684 (Accessed on 02/12/2019)

Upham, P., and Shackley, S. (2007). Local public opinion of a proposed 21.5 MW(e) biomass gasifier in Devon: Questionnaire survey results. *Biomass and Bioenergy*, 31(6), 433–441. https://doi.org/10.1016/j.biombioe.2007.01.017

Upham, Paul, Oltra, C., and Boso, À. (2015). Towards a cross-paradigmatic framework of the social acceptance of energy systems. *Energy Research and Social Science*, 8, 100–112. https://doi.org/10.1016/j.erss.2015.05.003

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5), 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

van Rijnsoever, F. J., van Mossel, A., and Broecks, K. P. F. (2015). Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews*, 45, 817–829. https://doi.org/10.1016/j.rser.2015.02.040

Vanhulle, A., Houthave, R., and Marcantonio, M. Di. (2010). Seascape and socio-economic study: final results. In *Offshore wind farms in the Belgian part of the North Sea: Early environmental impact assessment and spatio-temporal variability* (pp. 165–186). Brussels: Royal Belgian Institute of Natural Sciences. Management Unit of the North Sea Mathematical Models. Marine Ecosystem Management Unit. https://tethys.pnnl.gov/publications/offshore-wind-farms-belgian-part-north-sea-early-environmental-impact-assessment (Accessed on 02/12/2019)

Vorkinn, M., and Riese, H. (2001). Environmental Concern in a Local Context: The Significance of Place Attachment. *Environment and Behavior*, 33(2), 249–263. https://doi.org/10.1177/00139160121972972

Waldo, Å. (2012). Offshore wind power in Sweden-A qualitative analysis of attitudes with particular focus on opponents. *Energy Policy*, 41, 692–702. https://doi.org/10.1016/j.enpol.2011.11.033

Walker, G. (2009). Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. *Antipode*, 41(4), 614–636. https://doi.org/10.1111/j.1467-8330.2009.00691.x

Warren, C. R., Lumsden, C., O'Dowd, S., and Birnie, R. V. (2005). 'Green On Green': Public perceptions of wind power in Scotland and Ireland. *Journal of Environmental Planning and Management*, 48(6), 853–875. https://doi.org/10.1080/09640560500294376

Whitmarsh, L., Upham, P., Poortinga, W., McLachlan, C., Darnton, A., Devine-Wright, P., and Sherry-Brennan, F. (2011). *Public Attitudes, Understanding, and Engagement in relation to Low- Carbon Energy: A selective review of academic and non-academic literatures*. http://orca.cf.ac.uk/22753/ (Accessed on 02/12/2019)

Wilson, G. A., and Dyke, S. L. (2016). Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land Use Policy*, 52, 287–296. https://doi.org/10.1016/j.landusepol.2015.12.008

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy*, 21(1), 49–64. https://doi.org/10.1016/S0960-1481(99)00130-5

Wolsink, M. (2006). Invalid theory impedes our understanding: A critique on the persistence of the language of NIMBY. *Transactions of the Institute of British Geographers*, 31(1): 85–91. https://doi.org/10.1111/j.1475-5661.2006.00191.x

Wolsink, M. (2018). Social acceptance revisited: gaps, questionable trends, and an auspicious perspective. *Energy Research and Social Science, 46*, 287–295. https://doi.org/10.1016/j.erss.2018.07.034

Wolsink, M. (2019). Social acceptance, lost objects, and obsession with the 'public' – The pressing need for enhanced conceptual and methodological rigor. *Energy Research and Social Science*, 48, 269–276. https://doi.org/10.1016/J.ERSS.2018.12.006

Wüstenhagen, R., Wolsink, M., and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. https://doi.org/10.1016/J.ENPOL.2006.12.001

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

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3.1. Abstract

The deployment of RE 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 RE 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 GB 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.

3.2. Introduction

The deployment of RE 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 (Devine-Wright, 2007; Fast, 2013; Upham *et al.*, 2015). 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 (Wittneben, 2012), 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" (DECC, 2015).

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 (Sternberg, 2008), fracking for shale gas in the UK (Cotton, 2016), and controversial coal mining projects in Australia (Smyth, 2016). 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*. (2013) 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 high environmental hazards were frequently concentrated in minority and economically disadvantaged communities (Bullard, 1983; Freeman, 1972). Similar patterns have since been identified in many other countries such as Mexico, France and the UK (Mitchell *et al*., 2015; Stevens *et al*., 2008; Viel *et al*., 2011), 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 (Bouzarovski and Simcock, 2017; Gillard *et al*., 2017), the labour market (Healy and Barry, 2017), and infrastructure siting such as fracking and nuclear power (Clough and Bell, 2016; Kyne and Bolin, 2016). However, despite some recent academic attention (e.g. Liljenfeldt and Pettersson, 2017) the distributive elements of RE 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 (Walker, 2009). It demands appropriate and sympathetic engagement mechanisms (Todd and Zografos, 2005) and for the views of all stakeholders to be taken seriously throughout the decision-making process (McCauley *et al*., 2013). It also requires impartiality and full information disclosure by those in positions of authority, such as government and industry (Davies, 2006). 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 (Sovacool *et al.*, 2016). This tenet of energy justice has received greater attention in relation to RE than distributional justice, particularly relating to wind power siting decisions (e.g. Aitken *et al*., 2008; Gross, 2007; Simcock, 2016; Walker and Baxter, 2017). 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 (Schlosberg, 2007). 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 (McCauley *et al*., 2013). 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 GB. These are the two most commonly deployed land-based renewable technologies in the country (DUKES, 2016), 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. Ek *et al*., 2013; van der Horst and Toke, 2010) 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 3.3, we present a conceptual framework (Figure 7) 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 3.4, and results are presented in Section 3.5. Section 3.6 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 3.7 provides key conclusions and recommendations for future research.

3.3. Theory

Public acceptance can be divided into three dimensions (Wüstenhagen *et al*., 2007): *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 RE). 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. Figure 7 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 or 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 (Apostol *et al*., 2016; Scognamiglio, 2016; Wolsink, 2000). The type of land cover can also influence acceptance of these technologies (Betakova *et al*., 2015; Lothian, 2006). Other material arguments focus on environmental impacts and impacts on ES, for example bird collision with wind turbines, given the implications for biodiversity conservation (Gove *et al*., 2016). 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 (Brudermann *et al*., 2013; Enevoldsen and Sovacool, 2016; Gibbons, 2015; Healy and Barry, 2017). Finally, project details also contribute to material reasons for support or opposition, including the size of the project (Krohn and Damborg, 1999), irritations such as noise and shadow flicker in the case of onshore wind (Jensen et al, 2014) and glare in the case of solar farms (Minelli *et al*., 2014), as well as project ownership structures i.e. whether the project is owned and managed by a private company, individual or community group (Warren and McFadyen, 2010).

As well as material arguments, community acceptance can be affected by the attitudes and characteristics of local residents (Bishop and Miller, 2007; Toke, 2005). For example, demographic attributes can influence views towards RE, particularly age, with older people tending to be less accepting that younger people (Ladenburg and Dubgaard, 2007; van Rijnsoever *et al*., 2015). Demographic variables such as social deprivation can also influence the extent to which residents take action on RE 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 (Anderson, 2013; Rydin and Pennington, 2000). Political values and beliefs have also been found to influence attitudes towards and acceptance of RE developments (Bidwell, 2013), as well as temporal factors, with people tending to become more accepting as a result of exposure over time (Warren *et al*., 2005; Wilson and Dyke, 2016). 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 3.4. 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 3.6. 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.

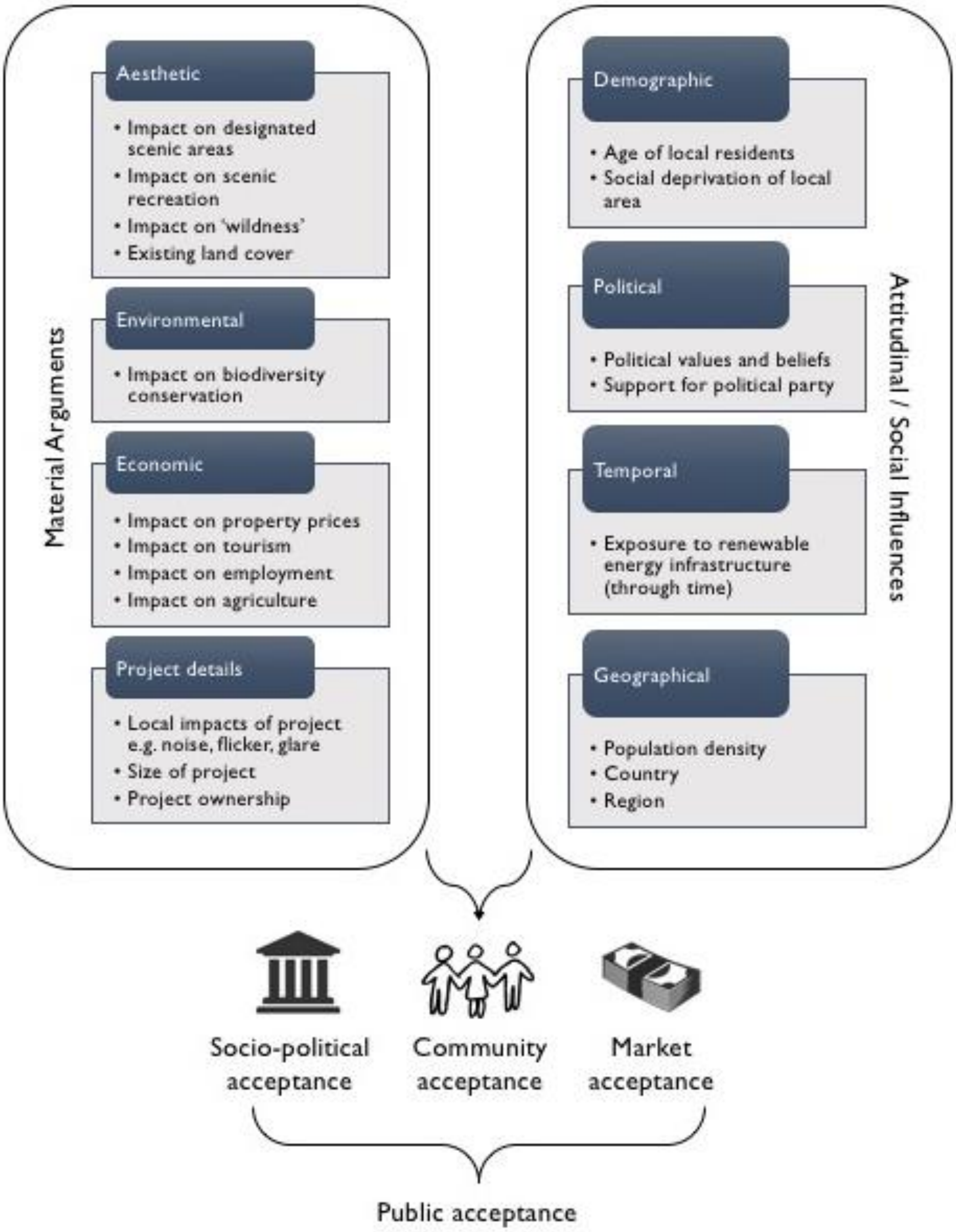

Figure 7. Framework of 'acceptance variables' contributing to community acceptance of onshore wind and solar farms based on authors' literature review, building on 'the triangle of social acceptance of renewable energy innovation' (Wüstenhagen *et al*., 2007)

3.4. Material and methods

3.4.1. 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 RE over this time period, as well as comparable data availability. Since the early 1990s, the configuration of the electricity supply system in GB has shifted from centralised conventional power stations and remote hydropower stations to increasingly visible decentralised RE sources such as onshore wind and solar farms. Whilst receiving high general public approval ratings of between 64-73% (onshore wind) and 80-87% (solar) in the UK Government's PAT since the survey began in 2012 (BEIS, 2017), the deployment of these technologies has frequently been marked by public opposition at the local level (Clark, 2013; Simcock, 2016). 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 RE 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 (DCLG, 2017). 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 Portal, 2017). 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 within the relevant jurisdiction, the applicant has the right of appeal. In this case, the decision on the appeal is made by decision-makers in central government.

3.4.2. Data collection

Planning data for onshore wind and solar farms were obtained from the UK 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 (BEIS, 2017a). 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 2). The variables were selected based on the conceptual framework presented in Section 3.3. 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.

Table 2. 'Acceptance variables' used to test the effect of community acceptance on planning outcomes for onshore wind and solar farms in Great Britain (1990 – 2017)

Category of variable		Acceptance variable	Indicator used for variable	Unit of analysis	Data source(s)	Data year(s)
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)
		Impact on scenic recreation	Distance to National Parks	Distance to feature (km)	NE, NRW, SG	2010 (NRW), 2011 (SG), 2016 (NE),
		Impact on 'wildness'	Naturalness*	Naturalness score (1-256), 50x50m cell	Authors' data	2016
			Ruggedness*	Ruggedness score (1-256), 50x50m cell	Authors' data	2016
			Remoteness*	Remoteness score (1-256), 50x50m cell	Authors' data	2016
			Visibility of modern artefacts and structures*	Visibility score (1-256), 50x50m cell	Authors' data	2016
		Existing land cover	Land cover category	Joint Nature Conservation Committee (JNCC) Broad Habitat Types, 25x25m cell	Centre for Ecology and Hydrology (CEH)	1990, 2000, 2007, 2015
	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)
			Special Areas of Conservation (SACs)	Distance to feature (km)	NE, NRW, SNH	2016 (NRW, SNH), 2017 (NE)
			Special Protection Areas (SPAs)	Distance to feature (km)	NE, NRW, SNH	2010 (NRW) 2016 (NE, SNH)
			Ramsar sites (Wetlands of International Importance)	Distance to feature (km)	NE, NRW, SNH	2010 (NRW), 2012 (SNH), 2016 (NE)
			National Nature Reserves	Distance to feature (km)	NE, NRW, SNH	2016 (NE, NRW, SNH)
			Local Nature Reserves	Distance to feature (km)	NE, NRW, SNH	2016 (NE, NRW, SNH)
	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)
		Impact on tourism	Tourist visits	Number of visits to county (staying 1+ night)	Visit Britain	2002 – 2016
		Impact on local employment	Employment in renewable energy sector	Number of jobs in region	Renewable Energy Association (REA)	2010 – 2015
	Project details	Project size	Installed capacity	Megawatt	REPD	2017
			Turbine capacity (wind only)	Megawatt	REPD	2017
		Project ownership structure	Name of operator or applicant in REPD	Private or community/individual ownership	REPD	2017

Table continued overleaf

Category of variable		Acceptance variable	Indicator used for variable	Unit of analysis	Data source(s)	Data year(s)
Attitudinal/ social influences	Demographic	Age of residents	16-24 year olds	Percentage of total population in LAD	UK Census	1991, 2001, 2011
			65+ year olds	Percentage of total population in LAD	UK Census	1991, 2001, 2011
		Social deprivation	Townsend Index	Townsend Index score of LAD	Authors' data, calculated from the UK Census	1991, 2001, 2011
	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
	Temporal	Exposure to renewable energy infrastructure	Date of planning application	Year	REPD	2017
	Geographical	Geographical location	Country in GB	Country (England, Scotland, Wales)	REPD	2017
			Population density	Persons per hectare in LAD	UK Census	1991, 2001, 2011

* These indicators follow the methodology in Carver et al (2012) 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.

** 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 50MW, 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.

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).

NB. 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 was also excluded from the solar farm model as this refers to the capacity of wind turbines, so is not relevant to solar farms.

3.4.3. 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 3). 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 2 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 2.1km$_2$ (18.9 MW) and the average area of a solar farm is approximately 0.4km$_2$ (8.1 MW), based on the land use estimates for these technologies recommended by Gove *et al*. (2016). 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 (Mitchell and Norman, 2012).

Table 3. 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.

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 (Openshaw, 1984). 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 3.6. Visualisation of the administrative geographies of GB is available in Supporting Information in Appendix 1 (Figure 26).

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 (Tabachnick and Fidell, 2014). Multicollinearity between independent variables was measured by the variance inflation factor (VIF), and coefficients with a VIF greater than 2.5 were removed (Midi *et al*., 2010) (see Table 2). 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 2) 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.

3.5. 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 Figure 9). 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 (STA, 2016). Applications for onshore wind were more diffuse without a clear spatial pattern (see Figure 8). Figures 9 and 10 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 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 4) and 8 of the 24 variables included in the solar model were statistically significant (see Table 5). 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.

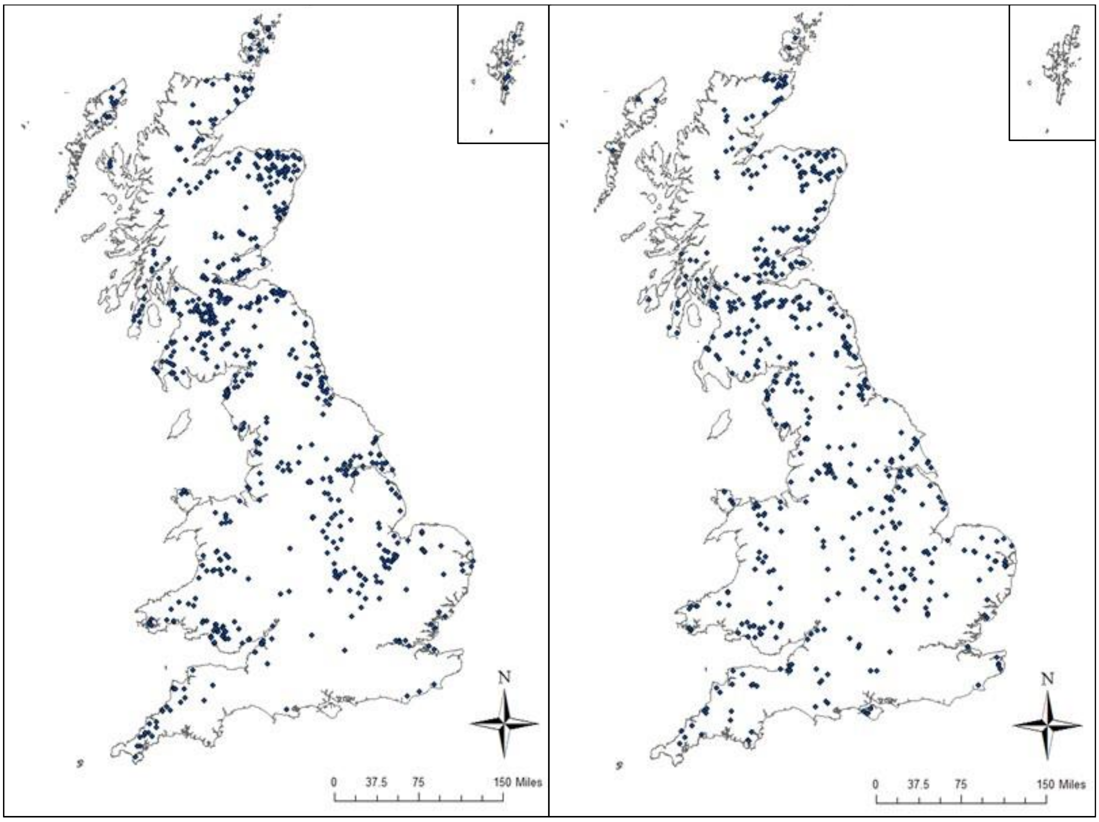

Figure 8. Left: Positive planning outcomes (*n* = 756); Right: Negative planning outcomes (*n* = 568) for onshore wind in Great Britain (1990 – 2017)

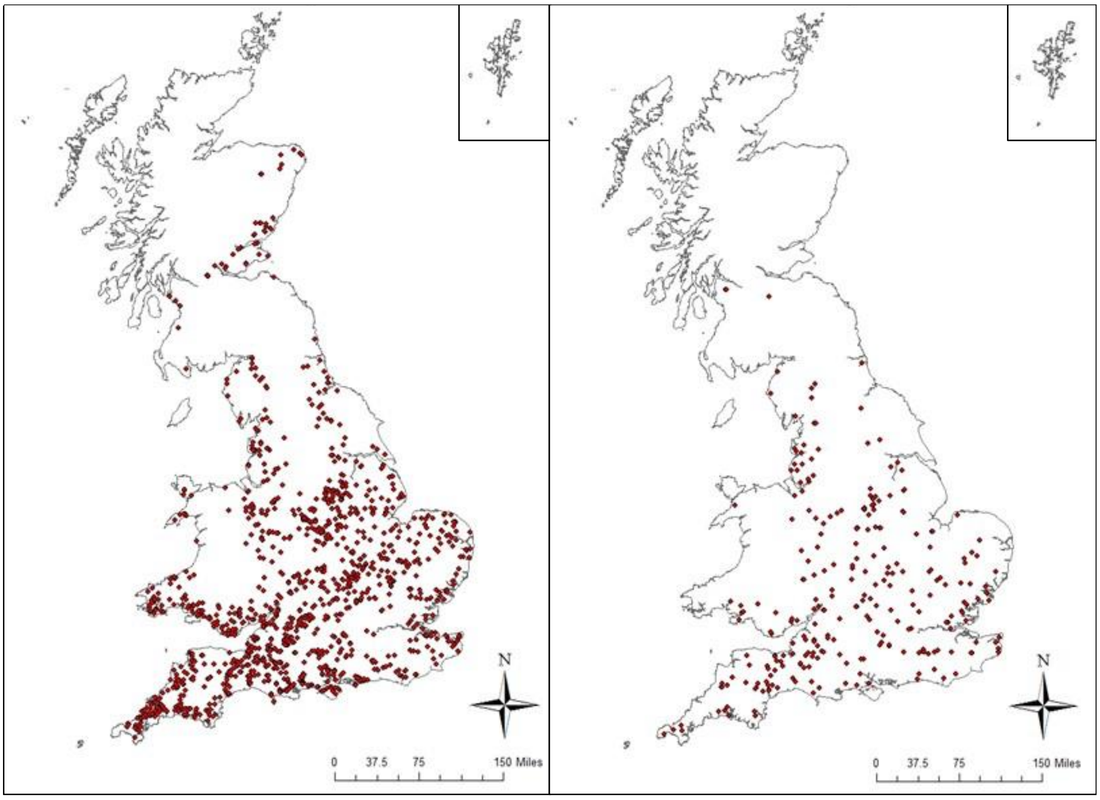

Figure 9. Left: Positive planning outcomes (*n* = 1277); Right: Negative planning outcomes (*n* = 283) for solar farms in Great Britain (1990 – 2017)

Table 4. Statistically significant variables associated with positive planning outcomes for onshore wind planning applications ($p <= 0.05$)

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 5. Statistically significant variables associated with positive planning outcomes for solar farm planning applications ($p <= 0.05$)

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	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

3.6. Discussion

3.6.1. 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. Pasqualetti *et al.*, 2002; Scognamiglio, 2016; Wolsink, 2000). Variables from seven of the eight sub-categories in our conceptual framework (Figure 7) 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' (Blowers, 1993), 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. Krogh, 2011). Whilst for some people the cultural ES 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 (Ellis *et al.*, 2007). 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 (Burke, 2015; Smith, 2016). 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 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 1km 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 2.1-2.8 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 ES such as biodiversity protection and agricultural production coming into conflict with RE production, and potentially influencing the acceptability of RE 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 (Anderson, 2013; Rydin and Pennington, 2000). 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 RE than less affluent communities, meaning that developments are becoming concentrated in deprived areas as a result. Another possible explanation for these trends is that, as 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' (van der Horst, 2007), meaning that people in deprived communities (often overlapping with ex-mining and ex-industrial areas) are more accepting of 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 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 RE infrastructure, in contrast to studies which found that attitudes improved with exposure through time (e.g. Warren *et al*., 2005). 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. Bidwell, 2013) 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 MAUP 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.

3.6.2. 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 RE 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. Liljenfeldt and Pettersson, 2017; van der Horst and Toke, 2010), 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 RE deployment and improving public acceptance at multiple levels.

As Wüstenhagen *et al*. (2007) 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 RE policy outputs has been found in relation to public opinion on prioritising the environment (Anderson *et al*., 2017). 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 PAT, 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 policymaking process is being driven by priorities other than public acceptance.

As Siegrist *et al*. (2014) 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 policymaking process in order to make it more deliberative, which social science research suggests can help to increase overall acceptance of decisions (Stevenson and Dryzek, 2012). 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 (Tabi and Wüstenhagen, 2017).

3.7. 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 RE 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.

3.8. References

Aitken, M., McDonald, S., and Strachan, P. (2008). Locating "power" in wind power planning processes: the (not so) influential role of local objectors. *Journal of Environmental Planning and Management*, 51(6), 777–799. http://doi.org/10.1080/09640560802423566

Anderson, B., Bohmelt, T., and Ward, H. (2017). Public Opinion and Environmental Policy Output: A Cross-National Analysis of Energy Policies in Europe. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/aa8f80

Anderson, C. (2013). The networked minority: How a small group prevailed in a local windfarm conflict. *Energy Policy*, 58, 97–108. http://doi.org/10.1016/J.ENPOL.2013.02.048

Apostol, D., Palmer, J., Pasqualetti, M., Smardon, R., and Sullivan, R. (2016). *The Renewable Energy Landscape: Preserving Scenic Values in our Sustainable Future*. (D. Apostol, J. Palmer, M. Pasqualetti, R. Smardon, and R. Sullivan, eds.). Abingdon, Oxon; New York, NY: Routledge.

BEIS (Department of Business, Energy and Industrial Strategy). (2017). Energy and Climate Change Public Attitudes Tracker: Wave 21. https://www.gov.uk/government/statistics/energy-and-climate-change-public-attitude-tracking-survey-wave-21 (Accessed on 01/09/2017)

BEIS (Department of Business, Energy and Industrial Strategy). (2017a). Renewable energy planning database monthly extract. https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract (Accessed on 01/09/2017)

Betakova, V., Vojar, J., and Sklenicka, P. (2015). Wind turbines location: How many and how far? *Applied Energy*, 151, 23–31. http://doi.org/10.1016/j.apenergy.2015.04.060

Bidwell, D. (2013). The role of values in public beliefs and attitudes towards commercial wind energy. *Energy Policy*, 58, 189–199. http://doi.org/10.1016/j.enpol.2013.03.010

Bishop, I. D., and Miller, D. R. (2007). Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables.

Renewable Energy, 32, 814–831. http://doi.org/10.1016/j.renene.2006.03.009

Blowers, A. (1993). *Planning for a Sustainable Environment*. Town and Country Planning Association Report. London: Earthscan Publications.

Bouzarovski, S., and Simcock, N. (2017). Spatializing energy justice. *Energy Policy*, 107, 640-648. http://doi.org/10.1016/j.enpol.2017.03.064

Brudermann, T., Reinsberger, K., Orthofer, A., Kislinger, M., and Posch, A. (2013). Photovoltaics in agriculture: A case study on decision making of farmers. *Energy Policy*, 61, 96–103. http://doi.org/10.1016/j.enpol.2013.06.081

Bullard, Robert D. (1983). Solid Waste Sites and the Black Houston Community. *Sociological Inquiry*, 53(2-3), 273-288. https://doi.org/10.1111/j.1475-682X.1983.tb00037.x

Burke, M. (2015). Solar Farms: Funding, planning and impacts. House of Commons Library: Briefing Paper. https://researchbriefings.files.parliament.uk/documents/CBP-7434/CBP-7434.pdf (Accessed on 01/09/2017)

Carver, S., Comber, A., McMorran, R., and Nutter, S. (2012). A GIS model for mapping spatial patterns and distribution of wild land in Scotland. *Landscape and Urban Planning*, 104(3–4), 395–409. http://doi.org/10.1016/j.landurbplan.2011.11.016

Clark, Pilita. (2013). UK solar power rush sparks local protest. *Financial Times*. https://www.ft.com/content/0bc15800-043d-11e3-a8d6-00144feab7de?mhq5j=e5 (Accessed on 01/09/2017)

Clough, E., and Bell, D. (2016). Just fracking: a distributive environmental justice analysis of unconventional gas development in Pennsylvania, USA. *Environmental Research Letters*, 11(2), 25001. http://doi.org/10.1088/1748-9326/11/2/025001

Cotton, M. (2016). Fair fracking? Ethics and environmental justice in United Kingdom shale gas policy and planning. *Local Environment*, 1–18. http://doi.org/10.1080/13549839.2016.1186613

Davies, R, A. (2006). Environmental justice as subtext or omission: Examining discourses of anti-incineration campaigning in Ireland. *Geoforum*, 37, 708-724. https://doi.org/10.1016/j.geoforum.2005.06.005

DCLG (Department of Communities and Local Government). (2017). Consultation and pre-decision matters. https://www.gov.uk/guidance/consultation-and-pre-decision-matters (Accessed on 01/09/2017)

DECC (Department of Energy and Climate Change). (2015). Statement on ending subsidies for onshore wind. https://www.gov.uk/government/speeches/statement-on-ending-subsidies-for-onshore-wind (Accessed on 01/09/2017)

DUKES (Digest of UK Energy Statistics). (2016). Chapter 6: Renewable sources of energy. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577712/DUKES_2016_FINAL.pdf (Accessed on 01/09/2017)

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review. *Beyond Nimbyism: a multidisciplinary investigation of public engagement with renewable energy technologies. Working Paper No. 1.4*. http://www.sed.manchester.ac.uk/research/beyond_nimbyism/ (Accessed on 01/09/2017)

Ek, K., Persson, L., Johansson, M., and Waldo, Å. (2013). Location of Swedish wind power-Random or not? A quantitative analysis of differences in installed wind power capacity across Swedish municipalities. *Energy Policy*, 58, 135–141. http://doi.org/10.1016/j.enpol.2013.02.044

Ellis, G., Barry, J., and Robinson, C. (2007). Many ways to say "no", different ways to say "yes": Applying Q-Methodology to understand public acceptance of wind farm proposals. *Journal of Environmental Planning and Management*, 50(4), 517–551. http://doi.org/http://dx.doi.org/10.1080/09640560701402075

Enevoldsen, P., and Sovacool, B. K. (2016). Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews*, 53, 178–184. http://doi.org/10.1016/j.rser.2015.08

Fast, S. (2013). Social Acceptance of Renewable Energy: Trends, Concepts, and Geographies. *Geography Compass*, 7(12), 853–866. https://doi.org/10.1111/gec3.12086

Freeman, A.M. III. (1972). Distribution of environmental quality. In A. V. Kneese and B. T. Bower (Eds.), *Environmental quality Analysis: Theory and Method in the social sciences* (pp. 243-278). Baltimore: The John Hopkins Press.

Gibbons, S. (2015). Gone with the wind: Valuing the visual impacts of wind turbines through house prices. *Journal of Environmental Economics and Management*, 72, 177–196. http://doi.org/10.1016/j.jeem.2015.04.006

Gillard, R., Snell, C., and Bevan, M. (2017). Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom. *Energy Research and Social Science*, 29, 53–61. http://doi.org/10.1016/j.erss.2017.05.012

Gove, B., Williams, L. J., Beresford, A. E., Roddis, P., Campbell, C., Teuten, E., Langston, R.H.W., Bradbury, R. B. (2016). Reconciling Biodiversity Conservation and Widespread Deployment of Renewable Energy Technologies in the UK. *PloS One*, 11(5), e0150956. http://doi.org/10.1371/journal.pone.0150956

Gross, C. (2007). Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance. *Energy Policy*, 35(5), 2727–2736. http://doi.org/10.1016/j.enpol.2006.12.013

Healy, N., and Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition". *Energy Policy*, 108, 451–459. http://doi.org/10.1016/j.enpol.2017.06.014

Jensen, C. U., Panduro, T. E., and Lundhede, T. H. (2014). The Vindication of Don Quixote: The Impact of Noise and Visual Pollution from Wind Turbines. *Land Economics*, 90(4), 668–682. http://doi.org/10.3353/lde.2014.0038

Krogh, C. M. E. (2011). Industrial Wind Turbine Development and Loss of Social Justice? *Bulletin of Science, Technology and Society*, 31(4), 321–333. http://doi.org/10.1177/0270467611412550

Krohn, S., and Damborg, S. (1999). On public attitudes towards wind power. *Renewable Energy*, 16(1–4), 954–960. http://doi.org/10.1016/S0960-1481(98)00339-5

Kyne, D., and Bolin, B. (2016). Emerging Environmental Justice Issues in Nuclear

Power and Radioactive Contamination. *International Journal of Environmental Research and Public Health*, 13(7). http://doi.org/10.3390/ijerph13070700

Ladenburg, J., and Dubgaard, A. (2007). Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark. *Energy Policy*, 35(8), 4059–4071. http://doi.org/10.1016/j.enpol.2007.01.023

Liljenfeldt, J., and Pettersson, Ö. (2017). Distributional justice in Swedish wind power development – An odds ratio analysis of windmill localization and local residents' socio-economic characteristics. *Energy Policy*, 105, 648–657. http://doi.org/10.1016/j.enpol.2017.03.007

Lothian, A. (2006). *Visual Impact Assessment of Wind Farms in South Australia*. In New Zealand Association for Impact Assessment Conference. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.553.1249andrep=rep1andtype=pdf (Accessed on 01/09/2017)

McCauley D, Heffron R, Stephan, H and Jenkins, K. (2013). Advancing Energy Justice: The Triumvirate of Tenets. *International Energy Law Review*, 32(3), 107–110. https://www.stir.ac.uk/research/hub/publication/709899

Midi, H., Sarkar, S. K., Rana, S., Midi, H., and Rana, S. (2010). Collinearity diagnostics of binary logistic regression model. *Journal of Interdisciplinary Mathematics*, 13(3), 253–267. http://www.tandfonline.com/doi/pdf/10.1080/09720502.2010.10700699

Minelli, A., Marchesini, I., Taylor, F. E., De Rosa, P., Casagrande, L., and Cenci, M. (2014). An open source GIS tool to quantify the visual impact of wind turbines and photovoltaic panels. *Environmental Impact Assessment Review*, 49, 70–78. http://doi.org/10.1016/j.eiar.2014.07.002

Mitchell, G., and Norman, P. (2012). Longitudinal environmental justice analysis: Co-evolution of environmental quality and deprivation in England, 1960-2007. *Geoforum*, 43, 44–57. http://doi.org/10.1016/j.geoforum.2011.08.005

Mitchell, G., Norman, P., and Mullin, K. (2015). Who benefits from environmental policy? An environmental justice analysis of air quality change in Britain, 2001–2011. *Environmental Research Letters*, 10(10), 105009. http://doi.org/10.1088/1748-9326/10/10/105009

Openshaw, S. (1984). *The Modifiable Areal Unit Problem*. Norwich, England:

Geobooks.

Pasqualetti, M. J., Gipe, P., and Righter, R. W. (2002). A landscape of power. In M. J. Pasqualetti, P. Gipe, and R. W. Righter (Eds.), *Wind Power in View: Energy Landscapes in a Crowded World*. San Diego: Academic Press.

Planning Portal. (2017). The decision-making process. https://www.planningportal.co.uk/info/200126/applications/58/the_decision-making_process (Accessed on 01/09/2017)

Rydin, Y., and Pennington, M. (2000). Public participation and local environmental planning: the collective action problem and the potential of social capital. *Local Environment*, 5(2), 153–169. http://doi.org/10.1080/13549830050009328

Schlosberg, D., (2007). Defining environmental justice: theories, movements and nature. Oxford: Oxford University Press.

Scognamiglio, A. (2016). "Photovoltaic landscapes": Design and assessment. A critical review for a new transdisciplinary design vision. *Renewable and Sustainable Energy Reviews*, 55, 629–661. http://doi.org/10.1016/j.rser.2015.10.072

Siegrist, M., Sütterlin, B., and Keller, C. (2014). Why have some people changed their attitudes toward nuclear power after the accident in Fukushima? *Energy Policy*, 69, 356–363. http://doi.org/10.1016/j.enpol.2014.02.026

Simcock, N. (2016). Procedural justice and the implementation of community wind energy projects: A case study from South Yorkshire, UK. *Land Use Policy*, 59, 467–477. http://doi.org/10.1016/j.landusepol.2016.08.034

Smith, L. (2016). Planning for onshore wind farms. *House of Commons Library: Briefing Paper.* https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN04370 (Accessed on 01/09/2017)

Smyth, Luke. (2016). Adani's Carmichael mine, international law and the definition of consent. *Native Title Newsletter*, 6-8. http://classic.austlii.edu.au/au/journals/NativeTitleNlr/2016/16.pdf (Accessed on 01/09/2017)

Sovacool, B. K., Heffron, R. J., McCauley, D., Goldthau, A., Jones, B. R., Sovacool, B., and Carvalho, A. (2016). Energy decisions reframed as justice and ethical concerns. *Nature Energy*, 1(5), 16024. http://doi.org/10.1038/nenergy.2016.24

STA (Solar Trade Association). (2016). STA Scotland: key facts and statistics. http://www.solar-trade.org.uk/wp-content/uploads/2016/03/Key-facts-and-statistics-Solar-in-Scotland-v8.pdf (Accessed on 01/09/2017)

Sternberg, R. (2008). Hydropower: Dimensions of social and environmental coexistence. *Renewable and Sustainable Energy Reviews*, 12(6), 1588–1621. http://doi.org/10.1016/j.rser.2007.01.027

Stevens, G. A., Dias, R. H., and Ezzati, M. (2008). The effects of 3 environmental risks on mortality disparities across Mexican communities. *Proceedings of the National Academy of Sciences*, 105(44), 16860-16865. https://doi.org/10.1073/pnas.0808927105

Stevenson, H., and Dryzek, J. S. (2012). The discursive democratisation of global climate governance. *Environmental Politics*, 21(2), 189-210. https://doi.org/10.1080/09644016.2012.651898

Tabachnick, B.G., and Fidell, L.S. (2016). *Using multivariate statistics* (6th ed.). Essex, UK: Pearson.

Tabi, A., and Wüstenhagen, R. (2017). Keep it local and fish-friendly: Social acceptance of hydropower projects in Switzerland. *Renewable and Sustainable Energy Reviews*, 68, 763–773. http://doi.org/10.1016/j.rser.2016.10.006

Todd, H. and Zografos, C. (2005). Justice for the Environment: Developing a Set of Indicators of Environmental Justice for Scotland. *Environmental Values*, 14(4): 483- 501. https://www.jstor.org/stable/30302087

Toke, D. (2005). Explaining wind power planning outcomes: Some findings from a study in England and Wales. *Energy Policy*, 33(12), 1527–1539. http://doi.org/10.1016/j.enpol.2004.01.009

Upham, P., Oltra, C., and Boso, À. (2015). Towards a cross-paradigmatic framework of the social acceptance of energy systems. *Energy Research and Social Science*, 8, 100–112. http://doi.org/10.1016/j.erss.2015.05.003

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5), 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

van der Horst, D., and Toke, D. (2010). Exploring the landscape of wind farm developments; local area characteristics and planning process outcomes in rural England. *Land Use Policy*, 27(2), 214–221. http://doi.org/10.1016/j.landusepol.2009.05.006

van Rijnsoever, F. J., van Mossel, A., and Broecks, K. P. F. (2015). Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews*, 45, 817–829. http://doi.org/10.1016/j.rser.2015.02.040

Viel, J. F., Hagi, M., Upegui, E., and Laurian, L. (2011). Environmental justice in a French industrial region: Are polluting industrial facilities equally distributed? *Health and Place*, 17(1), 257-262. https://doi.org/10.1016/j.healthplace.2010.10.007

Walker, C., and Baxter, J. (2017). Procedural justice in Canadian wind energy development: A comparison of community-based and technocratic siting processes. *Energy Research and Social Science*, 29, 160–169. http://doi.org/10.1016/j.erss.2017.05.016

Walker, G. (2009). Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. *Antipode*, 41(4), 614–636. http://doi.org/10.1111/j.1467-8330.2009.00691.x

Warren, C. R., Lumsden, C., O'Dowd, S., and Birnie, R. V. (2005). "Green On Green": Public perceptions of wind power in Scotland and Ireland. *Journal of Environmental Planning and Management*, 48, 853–875. http://doi.org/10.1080/09640560500294376

Warren, C. R., and McFadyen, M. (2010). Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. *Land Use Policy*. http://doi.org/10.1016/j.landusepol.2008.12.010

Wilson, G. A., and Dyke, S. L. (2016). Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land Use Policy*, 52, 287–296. http://doi.org/10.1016/j.landusepol.2015.12.008

Wittneben, B. B. F. (2012). The impact of the Fukushima nuclear accident on European energy policy. *Environmental Science and Policy*, 15(1), 1–3. http://doi.org/10.1016/J.ENVSCI.2011.09.002

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy*, 21(1), 49–64. http://doi.org/10.1016/S0960-1481(99)00130-5

Wüstenhagen, R., Wolsink, M., and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. http://doi.org/10.1016/j.enpol.2006.12.001

4. Accounting for taste? Analysing diverging public support for energy sources in Great Britain

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4.1 Abstract

Public acceptance of energy technologies is an important area of energy and social science research. However, few studies utilise large datasets which include spatial and temporal dimensions, as well as the demographic and attitudinal characteristics of survey respondents. In this paper, we analyse twenty-five waves of the UK Government's PAT: a large, nationally representative dataset spanning six years (2012 – 2018). This enables unique insights into trends in public acceptance across time, space and social groups, covering eight energy sources. We find differing profiles in terms of who supports which types of energy, with a key division between support for RE technologies on the one hand, and nuclear and fracking on the other. We also identify a growing gap between public and policymakers' attitudes to energy technologies which we argue must be bridged to ensure a smooth rapid transition that is acceptable to all.

4.2 Introduction

Given the widespread risks presented by climate change (IPCC, 2018), there is an imperative to transition from fossil fuels to low carbon energy sources. It is recognised that public acceptance is important for the effective implementation of energy policies and technologies (Anderson *et al*., 2017; Stokes and Warshaw, 2017), and, conversely, a lack of public acceptance can act as a barrier to their uptake (Pasqualetti, 2011; Wolsink, 2018). Public acceptance of energy sources, and how this can be explained, has thus become a prominent topic for energy social scientists in recent years (Devine-Wright *et al*., 2017; Gaede and Rowlands, 2018).

Against this backdrop, several research organisations and government bodies have started to measure public attitudes towards energy sources. Examples include the Eurobarometer (in the EU); the Afrobarometer (a pan-African series of attitudinal surveys); and the UK Government's PAT. The PAT was established in 2012 to 'understand and monitor' public attitudes towards energy and climate change (BEIS, 2018). Surveys such as these provide rich datasets for exploring the underlying patterns behind support and opposition to energy sources across societies. However, there has been limited use of such datasets in energy and social science research to date.

Early studies of public acceptance of energy sources and technologies used broad quantitative approaches such as opinion polls, capturing a 'snap-shot' of general trends and concerns at national or sub-national scales (Devine-Wright, 2007). More recently, there has been a shift to case-study based research methods to gain deeper insights into rationales behind public responses to energy sources and specific projects (e.g. Bailey *et al*., 2011; Venables *et al*., 2012; Whitmarsh *et al*., 2015; Wilson and Dyke, 2016). These studies indicate that a variety of factors shape public acceptance of energy sources and projects at local scales, including visual impacts, economic benefits, demographic characteristics, and environmental attitudes.

However, the localised geographic scales of such case-based studies limits wider understanding of broader national trends, and subsequent relevance to national policy. Thus, as countries progress further into their implementation of low carbon transition plans, it becomes valuable to utilise the large-scale datasets that have been gathered over time, and to apply more advanced quantitative techniques to identify what shapes public support for energy sources at a national scale. This type of analysis is valuable to researchers and policymakers alike who are interested in energy policy and technology implementation across time, space and social groups.

In this paper, we develop and test five hypotheses to understand which variables explain public support for a range of energy sources at the national level. Our hypotheses are informed by the conceptual framework proposed by Roddis *et al*.

(2018), in which they identify eight categories relating to community acceptance of RE projects: aesthetic, geographical, temporal, demographic, political, economic, environmental, and project details. We apply this framework to consider socio-political acceptance i.e. support for energy sources or policies at a general level, typically gauged by large-scale surveys (Wüstenhagen *et al*., 2007). Community acceptance, on the other hand, refers to the 'specific acceptance of siting decisions and renewable energy projects by local stakeholders' (Wüstenhagen *et al*., 2007, p2685). We therefore exclude the 'project details' category as it describes variables relating to the acceptance of individual energy projects, rather than support for energy sources at the socio-political level i.e. general attitudes.

Whilst some existing studies do explore factors shaping socio-political acceptance of energy sources (e.g. Bertsch *et al*., 2017; Ribeiro *et al*., 2018), there are a lack of studies investigating this topic using large-scale datasets that include spatial and temporal dimensions, as well as the demographic and attitudinal characteristics of respondents. This paper contributes to this research gap by analysing twenty-five 'waves' (i.e. quarterly surveys) of the UK PAT: a large, nationally representative dataset spanning from July 2012 to April 2018 (n = 52,525). Data on the location of respondents were made available to the authors at the regional level, enabling unique geographical insights into this dataset. We cover eight energy sources: RE (in general), onshore wind, biomass, offshore wind, wave/tidal, solar, nuclear, and fracking. Given that much of the existing public acceptance literature focuses on wind energy (Fast, 2013; Gaede and Rowlands, 2018), our study thus contributes timely evidence from across the energy technology spectrum.

4.2.1. Research hypotheses

A key debate in the literature on public acceptance of energy sources is on the effect of familiarity on people's attitudes. It has traditionally been assumed, particularly outside of academic debates, that opposition can be explained by NIMBYism (van der Horst, 2007). This assumes that although people may support an energy source in principle (socio-political acceptance), they are opposed to hosting projects in their local area (community acceptance). However, the concept of NIMBYism has been widely critiqued (e.g. Wolsink, 2000) and there is limited empirical evidence to support it. Whilst some studies find substantiating evidence for NIMBY attitudes (e.g. Swofford and Slattery, 2010), many studies find that living close to energy projects, and thus having increased familiarity with that energy source, actually increases general support (e.g. Michaud *et al*., 2008; Venables *et al*., 2012; Warren *et al*., 2005). This has been dubbed the 'inverse NIMBY' syndrome by energy social science researchers (Warren *et al*., 2005).

We are interested in whether increased familiarity with energy technologies and sources is linked to public attitudes, and what this means for NIMBY or inverse NIMBY theories. Our first hypothesis is therefore that support for energy sources is associated with people's familiarity with that technology, estimated through visual exposure, geographical location of the respondent (urban/rural), and exposure over time. This falls into the aesthetic, geographical and temporal categories of the Roddis *et al*. (2018) framework, given that familiarity is primarily a function of visual exposure, which is in turn influenced by spatial location of the respondent and the relevant energy infrastructure, as well as exposure over time.

Our second hypothesis relates to the effect of demographic characteristics on support for energy sources, belonging to the demographic category of the Roddis *et al*. (2018) framework. Several studies have found sociodemographic characteristics such as age, gender and social class to be important predictors of attitudes to energy sources. In general, research suggests that younger people and women are more likely to support RE (Bishop and Miller, 2007; Ladenburg and Dubgaard, 2007; Ladenburg *et al*., 2013; van Rijnsoever *et al*., 2015), whilst older people and men are more likely to support nuclear and fracking (Boudet et al., 2014; Corner *et al*., 2011; Whitmarsh *et al*., 2015). However, there is some disagreement in the literature in terms of gender effects (Bertsch *et al*., 2017). Higher social classes have been found to be associated with greater support for renewable energy, nuclear *and* hydrocarbons (Corner *et al*., 2011; Devine-Wright, 2007; Whitmarsh *et al*., 2015). We will use the PAT dataset to test the hypothesis that sociodemographic characteristics can predict socio-political acceptance of energy sources and explore to what extent this matters over other variables.

A number of studies highlight the role of political values in accounting for public acceptance of RE sources (e.g. Apostol *et al*., 2016; Ek, 2005; Warren and Birnie, 2009). However, there is relatively little empirical evidence for this. A key exception is David Bidwell (2013), who finds that support for wind energy is strongly linked to traditional values as opposed to altruistic values. He therefore suggests that opposition to wind energy is 'fueled by conservativism' (p197), rather than by local concerns as suggested by NIMBY theories. Klick and Smith (2010), on the other hand, find no correlation between political party affiliation and support for wind energy. Other studies find that conservative political ideology is associated with greater support for nuclear power and hydrocarbons (e.g. Michaud *et al*., 2008; Whitfield *et al*., 2009). Our third hypothesis is therefore on the effect of political orientation on support for energy sources, which falls into the political category of the Roddis *et al*. (2018) framework. We predict that people living in more politically conservative regions (i.e. regions with greater numbers of parliamentary constituencies represented by the UK's Conservative Party) are less likely to support RE sources, and more likely to support nuclear and fracking.

A relatively under-studied aspect of public acceptance is the effect of employment in the energy sector on support for energy sources, belonging to the economic category of the Roddis *et al*. (2018) framework. If there is high employment in a particular energy sector within a geographical region (e.g. offshore oil and gas in North East Scotland), we might reasonably assume that people who live in that region are more likely to support that type of energy source due to the increased likelihood of affiliation(s) to that energy sector, such as direct employment or employment of a family member or friend. Jones *et al.* (2011) include this as a variable when investigating onshore wind in Northern England, but do not find it to be a significant predictor of support. However, qualitative research on wind, solar and biodiesel in Spain finds that local employment opportunities enhanced public support for these energy sources in some circumstances (del Rio and Burguillo, 2009). Our fourth hypothesis is therefore that support for energy sources is positively associated with regional employment in the related energy sector.

Finally, given the significant role of energy generation in contributing to GHG emissions, we intuitively expect concern about climate change to contribute to socio-political acceptance of energy sources. Our fifth hypothesis therefore relates to beliefs about climate change on support for energy sources, falling into the environmental category of the Roddis *et al.* (2018) framework. Given their differing carbon emission profiles, we predict that people with higher concern for climate change are more likely to support RE sources and less likely to support fracking (i.e. hydraulic fracturing to extract shale gas, a type of fossil fuel). In terms of nuclear power, in line with other studies (e.g. Hansla *et al*., 2008; Spence *et al*., 2010) we predict that people with higher climate concern are less likely to support nuclear, despite it having lower carbon emissions than fossil fuels, due to wider environmental and ethical concerns such as radioactive waste disposal.

4.3. Materials and methods

4.3.1. The PAT dataset

The PAT is a quarterly survey of UK residents (aged 16+) established by the UK Government in 2012. Topics covered include energy bills, energy security, energy technologies, and energy saving.[2] Each wave of the survey contains approximately 2,100 observations. Data is collected using face-to-face in-home interviews, conducted by computer assisted personal interviewing. A central set of questions is asked annually and a subset of questions is asked quarterly where attitudes are subject to greater variability e.g. if they may vary between seasons (DECC, 2014). The survey uses a random sampling quota method, in which respondents are drawn from a small set of homogenous streets in sample areas. Sample areas are selected by their similar population sizes identified through UK census small area statistics,

[2] The content of the PAT was changed in August 2018 (Wave 26 onwards) to reflect the expanded remit of BEIS following the merger between the Department for Business, Innovation and Skills (BIS) and the Department for Energy and Climate Change (DECC) in July 2016.

and sampling points must be contained within a single UK region.[3] Quotas are set in terms of characteristics known to influence the likelihood of being at home in order to minimise sampling bias (DECC, 2014). Different sampling points are used for each wave of the survey i.e. the same participants are not returned to in each wave, as they would be if the data collection was following a longitudinal design.

PAT data are available on the website of the UK Department of Business, Energy and Industrial Strategy (BEIS). Our analysis includes all waves up to and including Wave 25, spanning the period July 2012 to April 2018. Sociodemographic data is collected for all survey respondents, including age group, gender, working status, tenure, social grade, household income, and area type (urban/rural). The region where the respondents were sampled from was obtained by permission of BEIS under the UK ONS Accredited Researcher Scheme. Whilst this allows for spatial analysis of the data, it should be noted that UK regions are relatively large geographical areas meaning the granularity of the spatial analysis is quite low. Despite this limitation, the dataset is one of the most extensive of its kind containing geographical data, meaning it is uniquely placed to offer spatial insights into support for energy sources, as well as how other variables are associated with support.

The PAT measures attitudes to energy sources on a five-point scale, ranging from 'Strongly support' to 'Strongly oppose'. It also allows a 'Don't know' response. To avoid small sample sizes, which could potentially compromise the confidentiality of respondents, we collapsed these categories into three levels: Support (including 'Support' and 'Strongly support'), Neutral (including 'Neither support or oppose') and Oppose (including 'Oppose' and 'Strongly oppose'). Reducing the responses from a five-point to a three-point scale, whilst necessary to avoid breaching stringent confidentiality rules of the ONS, meant that some nuance was lost in terms of predicting the likelihood of *strong* feelings of support or opposition. Reducing categories was also necessary to create a 'balanced' dataset (see Section 4.3.2).

[3] There are 12 UK regions (formerly known as Government Office Regions in England): North East, North West, Yorkshire and Humber, East Midlands, West Midlands, Eastern England, London, South East, South West, Wales, Scotland and Northern Ireland. The latter three are not Government Office Regions but are used by this study (and other studies) as equivalents.

PAT respondents who answered 'Don't know' were excluded from the analysis of that energy source as this does not provide relevant insights for our hypotheses. Respondents from Northern Ireland were also excluded from our analysis as low sample sizes from this region could again compromise confidentiality. The extent of the analysis is therefore GB (i.e. England, Scotland, and Wales). Not all waves of the PAT survey asked the questions relevant to our analysis, meaning our sample size varies between the energy sources (Table 6 shows sample sizes for each energy source and original wording of the questions in the PAT questionnaire).

Table 6. Number of waves (quarterly surveys) of the UK Government's Energy and Climate Change Public Attitudes Tracker between July 2012 and April 2018 (Waves 1 – 25) asking relevant questions to this study; sample sizes for each question; and original wording of the questions.

	Q3. Renewable energy	Q13a. Onshore wind	Q13b. Biomass	Q13c. Offshore wind	Q13d. Wave / Tidal	Q13e. Solar	Q14a. Nuclear	Q15b. Fracking
No. waves	25	19	19	19	19	19	23	18*
Total	52,525	39,859	39,859	39,859	39,859	39,859	48,304	37,801
Original wording in PAT	Do you support or oppose the use of renewable energy for providing our electricity, fuel and heat?	Generally speaking, do you support or oppose the use of the following renewable energy developments: a) On-shore wind b) Biomass – this includes any plant or animal base material such as wood, specially grown energy crops, and other organic wastes that can be used in the process of creating energy c) Off-shore wind d) Wave and tidal e) Solar					From what you know, or have heard about using nuclear energy for generat-ing electric-ity in the UK, do you support or oppose its use?	From what you know, or have heard about, extracting shale gas to generate the UK's heat and electricity, do you support or oppose its use?

* The PAT first asked question 15b in 2014; all other questions relevant to this study were asked since 2012.

4.3.2. Data analysis

Our analytical approach falls into the 'data analysis and statistics' category of research method for energy social science, as classified by Sovacool *et al*. (2018). To begin, we mapped the spatial variation in support for energy sources across GB in order to visualise the PAT dataset. To do this, we calculated the mean percentage of support for each of the eight energy sources in our study between April 2012 and July 2018 for the whole of GB. We then calculated the average difference from this mean in each of the geographical regions of the study area. To display this information, we created eight choropleth maps sharing the same colour ramp so that the difference between overall levels of support for energy sources was immediately clear (Figure 11). We then labelled each region with the difference from the mean of GB to show whether support in that region was higher or lower than the average, and to show the variance between regions.

We ran Mann-Kendall (MK) tests on annual time series of support between 2012 and 2018 (i.e. the percentage of PAT respondents answering support or strongly support for the energy source in each year) to identify whether there was a statistically significant monotonic trend, either increasing or decreasing. We chose to use MK tests as they are non-parametric, which is appropriate due to the limited number of data points when the data was disaggregated by year, meaning that normal distribution of the data cannot be confidently determined (Bonett and Wright, 2000). We added a time series plot to each of the choropleth maps to show how support for each energy source changed over the study period, and whether the trend was statistically significant at the 5% level. The spatial and time series analysis (as well as the regression analysis described below) was carried out using weighted data, applying the weighting provided by BEIS which is designed to make the data representative of the entire UK adult population (DECC, 2014).

To directly address our research hypotheses (Section 4.2.1), we used ordinal logistic regression (henceforth referred to as ordinal regression). Ordinal regression is a type of statistical analysis which assesses the relationship between an ordinal dependent variable, such as a Likert scale, and one or more independent variables. The type of ordinal regression used in this analysis is a generalised ordered logit model with partial proportional odds. Unlike the more common proportional odds model, this type of model does not assume that the effect (i.e. slope coefficient) of each independent variable is the same across all categories of the dependent variable (Williams, 2016). Instead, it tests the assumption of proportionality for each independent variable: for those which meet the assumption, a single slope coefficient is estimated; for those which do not, separate slope coefficients are estimated for each cumulative dichotomous categorisation of the response variable. We chose this type of model as diagnostic tests (following Bell and Dexter, 2000; O'Connell *et al*., 2008) showed that the assumption of proportional odds was not met by our data in many cases. The models were run in Stata 14 using the user-written program gologit2 (Williams, 2006).

A regression model was calculated for each of the eight energy sources in the study: RE (in general), onshore wind, biomass, offshore wind, wave/tidal, solar, nuclear, and fracking. The dependent variable was the PAT respondent's aggregated level of support for the energy source in question (either support, neutral or oppose). The independent variables were selected based on the hypotheses being tested (Table 7). The data for the independent variables were either obtained directly from the PAT itself or calculated from external data sources (see Supporting Information in Appendix 2 for full details). Social grade (a measure based on occupation, collected in the PAT) was used as a proxy for social class. Category A was treated as the highest social grade (referring to higher managerial, administrative or professional workers) and category E as the lowest social grade (referring to unemployed people, state pensioners and casual workers). All variables were matched to the appropriate survey year as far as data availability allowed. For example, to calculate parliamentary constituencies represented by the UK's Conservative Party, percentages were assigned to each region based on the most recent general election data (either 2010, 2015 or 2017). Multicollinearity between independent variables was measured using VIFs; following Kock and Lynn (2012) the VIF values deemed acceptable were those less than 3.3.

Initial analysis of the dataset showed that, for several energy sources, the levels of support are strongly skewed (Figure 10). The dataset can therefore be described as 'imbalanced' i.e. the frequency of observations in each response category are not comparable. Imbalanced datasets can cause problems in statistical analyses such as ordinal regression as their underlying algorithms expect balanced class distributions (He and Garcia, 2009). For this reason, an informed under-sampling approach was taken to subsetting the data. This has been shown to reduce the problems associated with imbalanced data in a variety of studies (e.g. Lin *et al.*, 2017; Liu *et al.*, 2006; Mishra, 2017; Tang and Zhang, 2006). Specifically, we generated five random subsets for each energy source, based on the size of the minority class i.e. classes within each subset were created to be approximately the same size as the smallest class (Liu, 2009). By taking this approach (bootstrap aggregating or 'bagging'), we could train the models on a large number of samples whilst removing as the problem of class imbalance. The results of the models estimated for each of the random subsets were then combining by taking the average (mean) across the five models. This technique has been shown to provide substantial gains in model accuracy and helps to reduce variance error (Breiman, 1996). The generalised ordered logit model with partial proportional odds can be written as below, where M is the number of categories of the ordinal variable:

$$P(Y_i > j) = \frac{\exp\,(\alpha_j + X_i\beta_j)}{1 + [\exp(\alpha_j + X_i\beta_j)]}\ , j = 1, 2, \dots, \mathrm{M} - 1$$

Equation 1. Generalised ordered logit model with partial proportional odds

The outputs of ordinal regression models are ORs. For continuous variables, ORs greater than one indicate that the odds of a higher score of the dependent variable increase by this amount per one unit change; ORs less than one indicate decreased odds of a higher score per one unit change. For categorical variables, each category is compared to a reference or 'baseline' category (Table 7). The dependent variable was coded so that higher scores relate to increased support for an energy source (oppose = 1, neutral = 2, support = 3). Because of how generalised ordered logit models with partial proportional odds are calculated, ORs are generated for each cumulative dichotomous categorisation of the dependent variable (similar to a series of binary logit models). Therefore, the ORs generated by our regression models refer to the odds of being in the support category (vs neutral/oppose), and the neutral/support categories (vs oppose) i.e. the odds of getting a 'higher' score on the dependent variable scale.

Table 7. Variables included in the ordinal regression models to predict support for eight energy sources: renewable energy (in general), onshore wind, biomass, offshore wind, wave/tidal, solar, nuclear, and fracking.

Hypothesis	Category of conceptual framework	Independent variable	Data source for the variable
Familiarity effect (exposure to energy sources)	Aesthetic	Percentage of region where energy technology is visible (estimated using viewshed analysis techniques)	UK Renewable Energy Planning Database (REPD), Digest of UK Energy Statistics (DUKES), UK Oil and Gas Authority (OGA)*
	Geographical	Area type (urban area was compared to rural area)	UK Energy and Climate Change Public Attitudes Tracker (UK PAT)**
	Temporal	Year of the PAT survey	UK PAT
Effect of demographic characteristics	Demographic	Age group (ages 16-24, 25-34, 35-44, 45-54, and 55-64 were compared to age 65+)	UK PAT
		Gender (male was compared to female)	UK PAT
		Social Grade (A, B, C1, C2, and D were compared to E)	UK PAT
Effect of political orientation	Political	% parliamentary constituencies in region represented by the UK Conservative Party	UK Electoral Commission
Effect of employment in energy sector	Economic	% jobs in the related energy sector in region (of total regional employment)***	Renewable Energy Association (REA), Nuclear Industry Association (NIA), Oil and Gas UK (OGUK)
Effect of climate change concern	Environmental	Level of concern ('very', 'fairly', and 'not very' were compared to 'not at all')	UK PAT

* April 2018 monthly extract of the REPD; DUKES 2017; OGA Onshore Wells (OGA Open Data, 30/05/2018).
** Waves 1-25 (July 2012-April 2018). Includes survey questions 3, 13a, 13b, 13c, 13d, 13e, 14a, and 15b.
*** Employment figures refer to direct employment (as estimated by REA, NIA and OGUK industry reports). Total regional employment obtained from UK Labour Force Survey (A07: Regional Labour Market Summary).
For renewable energy sources, the whole renewable energy sector was used as the 'related energy sector' rather than disaggregating employment to the specific renewable technology sectors.

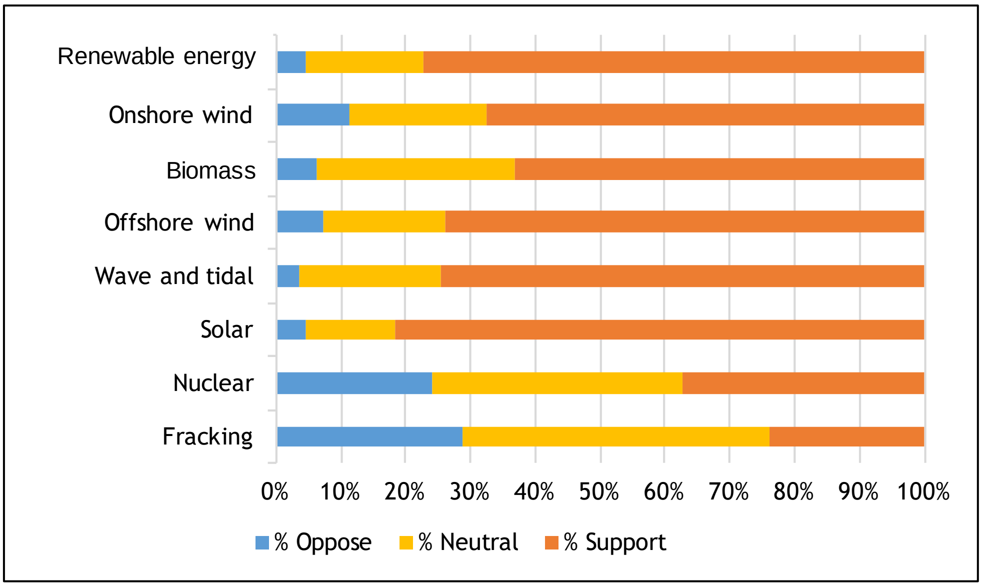

Figure 10. Levels of support for energy sources in Waves 1 to 25 of the UK Government's Energy and Climate Change Public Attitudes Tracker (July 2012 – April 2018). All statistical results remain Crown Copyright.

4.4. Results

Our results show that the energy source with the highest level of support in GB between July 2012 and April 2018 was solar, with a mean score of 80.1%. This was followed by RE (in general) which scored 76.8%, wave and tidal (74%), offshore wind (73.6%), onshore wind (66.7%) and biomass (62.5%). Nuclear and fracking had notably lower levels of support, with mean scores of 37.1% and 22.1% respectively. Support for all RE sources is increasing over time (Figure 11). These trends were statistically significant in the case of onshore wind, biomass, offshore wind, and wave/tidal energy ($p < 0.05$). Support for nuclear and fracking, on the other hand, was found to be decreasing over time. The trend in relation to nuclear was statistically significant ($p < 0.05$); the trend for fracking was very slightly short of statistical significance ($p = 0.08$), perhaps due to the fewer data points for this technology given that the PAT only began tracking its support in 2014, whilst the other energy sources began in 2012.

In terms of geographical variation, our results show an approximate North-South divide whereby more southerly regions of GB (other than London) tend to have higher average support for energy sources than more northerly regions (Figure 11).

Most notably, the South West and Eastern England have consistently above average support for most types of energy, whilst Scotland and London show consistently lower levels of support for all energy sources than other regions (Figure 11). This perhaps indicates that the familiarity effect follows a non-linear trend, given that London has the lowest rates of installed capacity for many energy technologies due to its high population density, whereas Scotland has consistently high rates of installed capacity (Table 14 in Supporting Information, Appendix 2). In other words, people *least* familiar and *most* familiar with energy technologies appear to have the lowest levels of support. Wales has notably low support for onshore wind, and the second highest level of installed capacity (after Scotland), supporting the idea of very high levels of exposure reducing support, perhaps due to perceptions of distributional injustice.

If urban and rural respondents are mapped separately (Figure 28) in Supporting Information, Appendix 2), similar patterns to those described above continue to pertain. Support for RE (in general), biomass, wave/tidal and solar was found to be higher in rural areas, whilst support for nuclear, fracking and wind energy (both onshore and offshore) was found to be higher in urban areas. A notable outlier is that rural respondents in North West England have much higher average levels of support for nuclear than their urban counterparts. This is potentially due to the elevated levels of rural employment in the nuclear sector in this part of GB, which hosted the world's first industrial-scale nuclear power facility (Calder Hall, opened in 1956) and continues to host several nuclear power stations and the Sellafield nuclear reprocessing facility (Kalantaridis and Bika, 2006).

As shown, mapping public attitudes to energy sources by region and area type can provide some insights into how attitudes vary geographically, and potential reasons why. In general, however, we found that the age group of the PAT respondent and their level of concern for climate change were stronger and more consistent predictors of support for energy sources than spatial variables (Figure 12). Our regression results indicate a divide between younger people, women and those with higher climate concern (who are more likely to support RE sources) and older people, men, and those with lower climate concern (who are more likely to support nuclear and fracking). The other independent variables used to test our hypotheses, particularly political and economic variables, had a less apparent and consistent effect on PAT respondents' likelihood of support for energy sources.

The regression models were best able to explain support for offshore wind, accounting for 19% of the variance (Nagelkerke R_2). This was followed by solar (18%), onshore wind (17%) and RE (in general) (17%). The models were weakest for wave and tidal energy (13%), fracking (13%), and nuclear (11%). All models were statistically significant ($p < 0.001$). Thus, although the independent variables included in our modelling clearly do have some explanatory power, a key finding of this paper is that they do not fully explain people's attitudes to energy sources (at least when these variables are calculated at the regional level). This is an important limitation to our analysis and suggests that regional-scale analysis is too coarse a resolution to fully explain people's attitudes. Alternatively, the lack of variance explained by our models could indicate that there are other factors influencing people's attitudes to energy sources which we have not modelled, or that there is random heterogeneity in the sample i.e. random individual differences in opinion.

Figure 12 shows the ORs for the independent variables included in each of the eight regression models. The first set of ORs (indicated by blue circles) refers to the odds of belonging to the support category, compared to the neutral/oppose categories (S vs N/O). The second set of ORs (indicated by orange circles) refers to the odds of belonging to the support/neutral categories, compared to the oppose category (S/N vs O). Where the OR is the same in both sets, the independent variable meets the proportional odds assumption; where it differs, it does not meet this assumption. As an example, the regression model for onshore wind estimated two ORs for the 'energy jobs' variable. The blue circle is above 1 and solid, showing a statistically significant ($p < 0.05$) positive effect for higher employment increasing the odds of being in the support category for onshore wind. The orange circle is below 1 and hollow, indicating a statistically insignificant ($p < 0.05$) negative effect for higher employment increasing the odds of being in the support and/or neutral categories.

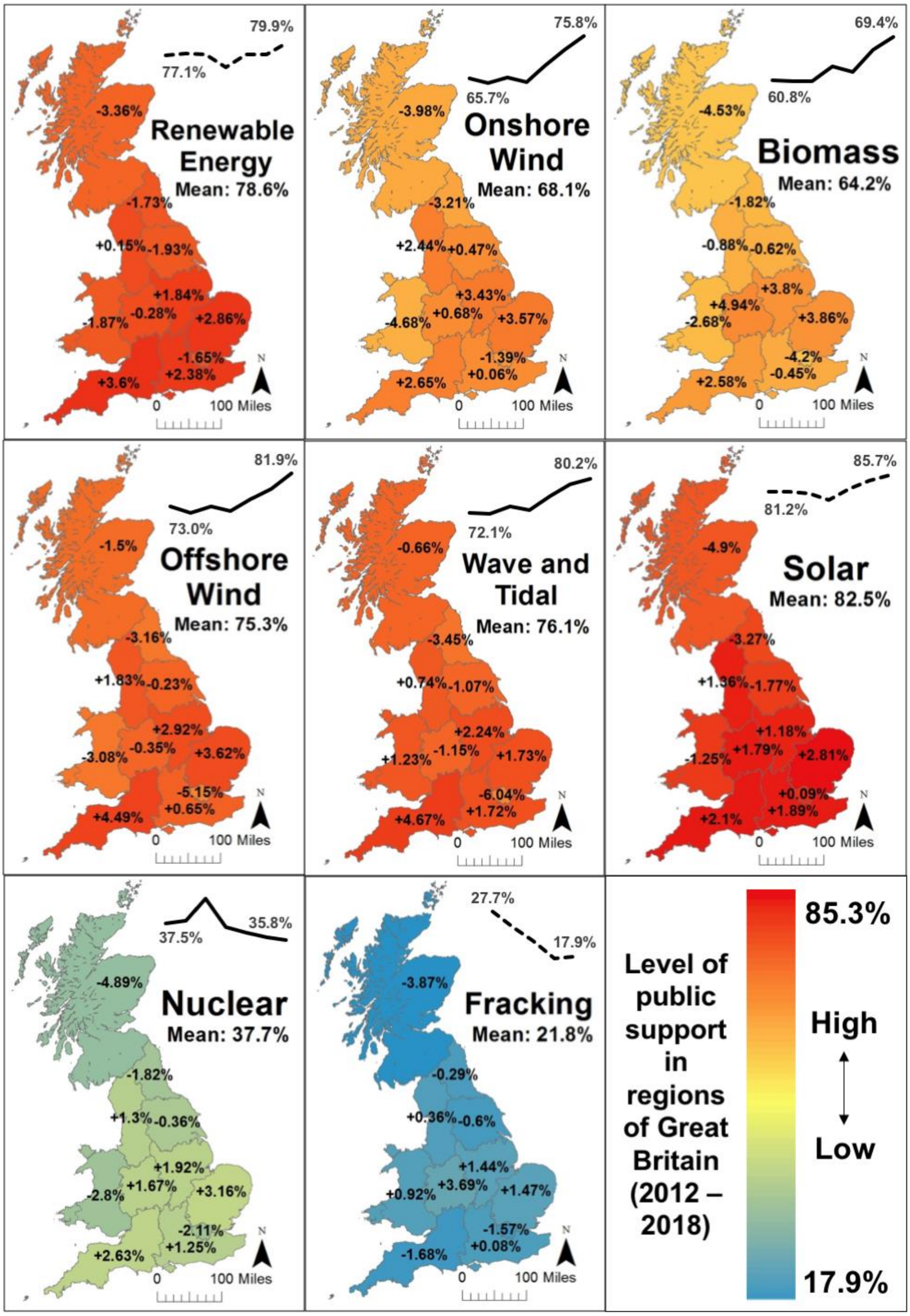

Figure 11. Support for energy sources in regions of Great Britain (2012 – 2018). Shetland Islands have the same results as the rest of Scotland. Labels show the difference from the mean level of support. Solid lines indicate time series has a statistically significant monotonic trend ($p < 0.05$). Data is from the UK Government's Energy and Climate Change Public Attitudes Tracker (Waves 1 – 25). All statistical results remain Crown Copyright.

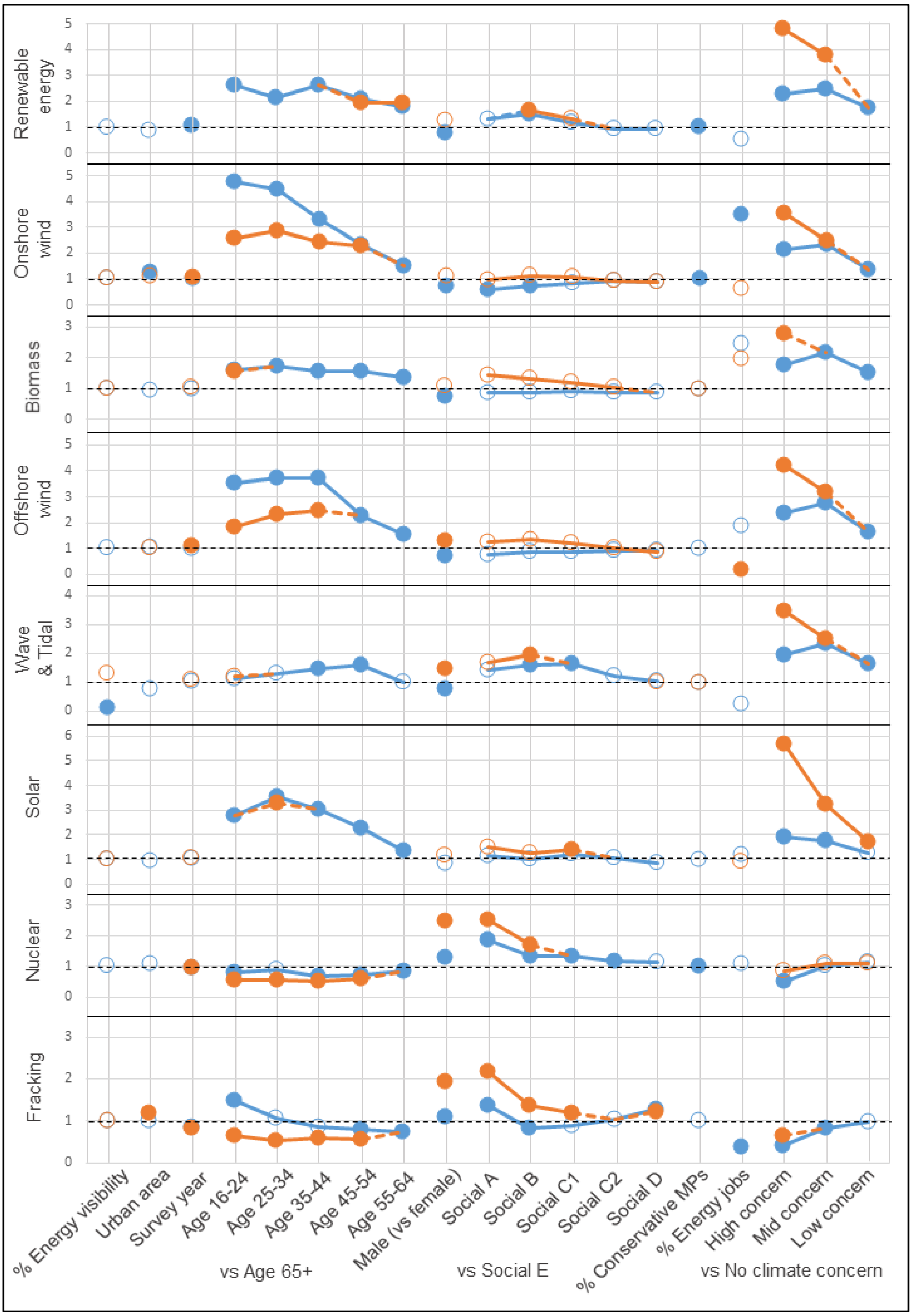

Figure 12. Scatter plots showing odds ratios (ORs) for variables used to predict support for energy sources. Blue circles show ORs for the support category compared to neutral/oppose categories. Orange circles show ORs for support/neutral categories compared to the oppose category. Where there is one circle, the same OR applies to both outcomes. Solid circles indicate statistically significant ORs ($p < 0.05$). ORs greater than 1 indicate positive effects; ORs less than 1 indicate negative effects. All statistical results remain Crown Copyright.

4.5. Discussion

4.5.1. The familiarity effect

We tested the effect of familiarity on people's support for energy sources using three independent variables: visual exposure, urban or rural dwelling, and the year in which the PAT respondent was surveyed. Our results show limited support for the familiarity effect via visual exposure. We predicted that increased visual exposure would have a positive effect on the likelihood of support as people would become accustomed to energy infrastructure being part of the visual landscape. Several studies have found aesthetic concerns to be prominent in explaining public acceptance of energy sources, particularly wind energy (e.g. Bishop and Miller, 2007; Rand and Hoen, 2017; Warren and Birnie, 2009; Wolsink, 2000), indicating the importance of visual impacts in informing attitudes. However, our results do not show that visual exposure had a statistically significant effect on people's likelihood of support for energy sources in either a positive or negative way.

The exception to our findings on visual exposure was in relation to wave and tidal energy. These energy sources are referred to collectively throughout this paper given that the PAT questionnaire collects attitudes to both together, meaning attitudes between them cannot be disaggregated. Our results showed there to be a statistically significant negative effect of visual exposure on support for these sources of energy. However, this result should be interpreted with caution given that there is currently very limited deployment of wave and tidal energy in GB (23 MW in South West England and 11 MW in Scotland, resulting in percentage exposure of 0.04% and 0.07% in these regions respectively). Additionally, these types of energy technology are often submerged underwater meaning they are sometimes not visible from land. We estimated an average height of 2m to account for the likelihood of some infrastructure (e.g. cabling, floats, buoys) being visible above the waterline. It should be noted that there are no tidal range projects in GB, such as dams or barrages spanning bays or estuaries, only tidal stream technologies such as underwater turbines (Todeschini, 2017).

The lack of significant effects regarding visual exposure could be explained by the low spatial resolution of those data. This analysis could be improved by using more finely grained georeferenced data on respondents' locations and mobility patterns. This would allow a better understanding of their exposure to energy infrastructure; however, such data are not currently available. Using total regional installed capacity as a predictor variable instead of visual exposure in the regression models was also not statistically significant. This analysis could further be improved upon by using more detailed height data (or MW/area) for energy installations, accounting for the trend towards larger infrastructure after 2012, to more accurately model landscape impacts. However, it could be that visual exposure to an energy source does not by itself alter people's attitudes; rather it could be the way in which energy installations change people's perceptions of landscapes and their attachment to places (Devine-Wright, 2009), which is very difficult to model at a national level.

Our results show that people living in urban areas were more likely than rural people to support wind energy (both onshore and offshore), nuclear, and fracking. A key exception is in relation to nuclear in the North West of England, which showed higher support in rural areas than urban areas, potentially due to employment effects (see Section 4.4). We found that people in rural areas were more likely than urban people to support RE (in general), biomass, wave/tidal, and solar. The only statistically significant results in our analysis, however, were in relation to onshore wind and fracking, which showed that contrary to our hypothesis on the familiarity effect, people in rural areas were *less* likely to support or be neutral towards these technologies. Given that these are both more suited to rural than urban areas, this suggests that people living closer to the impacts (or potential impacts) of onshore wind and fracking installations are less likely to support these technologies.

These findings somewhat contrast with other studies on this topic, particularly in relation to fracking. Other studies have identified stronger support in places closer to fracking sites. For example, Whitmarsh *et al*. (2015) find that out of three areas surveyed in the UK, the area in which fracking was already underway showed significantly more support than areas where it is not viable. Similarly, Boudet *et al*.

(2018) find that people in the US who live in closer proximity to fracking sites show greater support for the practice. The key difference between these studies and ours is that fracking has not taken place at a national scale in GB, meaning that socio-political attitudes are informed by hypothetical scenarios rather than direct experience. This could explain why our results do not show the same proximity effect as other studies do, or this may be because the resolution of analysis is coarser than other studies'. Alternatively, our findings may indicate that people in GB are *de facto* opposed to fracking, whether they have direct experience or not, as shown by the low average level of support for this technology (mean = 22%).

Our findings around temporal familiarity reveal a division between RE sources with nuclear and fracking. For RE (in general), onshore wind, and offshore wind, each year that passed between 2012 and 2018 increased people's likelihood of support or being neutral in a statistically significant way at the 5% level. For nuclear and fracking, however, each year that passed decreased the likelihood of people supporting or being neutral towards these technologies (this was statistically significant for nuclear at the 5% level and fracking at the 10% level). In other words, the likelihood of opposition to nuclear and fracking *increased* over this period, whilst it *decreased* for RE and wind energy. This could suggest that people have become more familiar with RE over time, in line with our hypothesis regarding the familiarity effect. For nuclear, there has not been any significant changes in the level of deployment over this time, meaning that its popularity has decreased despite the same levels of public exposure. Fracking has commenced in GB over this period, though at relatively slow pace, meaning that opposition has increased despite similar levels of public exposure.

Another explanation for the increase in support for RE sources between 2012 and 2018, and the decrease for fracking, is that concern for climate change has also increased over this time period (Figure 29 in Supporting Information, Appendix 2). For nuclear, it could be that the escalating costs of constructing new nuclear power stations such as Hinkley Point C are affecting people's attitudes in a negative way, particularly when the costs of many RE technologies are falling (Suna and Resch, 2016). There has been significant public debate in the UK about the financial cost of transitioning to low carbon energy, meaning that economic criteria may well be prominent in people's minds when asked about their support for energy sources. Another key socio-political issue which may have affected public attitudes over this period is the adoption of the UN Paris Agreement, which was agreed in 2015 with much publicity and ratified in 2016. This may have raised awareness of climate change and the urgency of mitigation measures, such as shifting from fossil fuels to low carbon energy sources (Lee *et al*., 2015; Drummond *et al*., 2018).

In summary, we did not find evidence for the familiarity effect via visual exposure, though this could be due to the limitations of modelling this variable at a regional scale. We found that onshore wind and fracking are *less* popular in rural communities than in cities, but RE (in general), solar, wave/tidal and biomass are *more* popular. Whilst this could be interpreted as NIMBYism in relation to onshore wind and fracking, and inverse NIMBYism for the others, it is difficult to draw firm conclusions on this given that our research design does not allow a strong understanding of *why* people feel the way they do. Indeed, when the results of our regression modelling are considered in conjunction with our spatial analysis, it suggests that more subtle considerations may be at play, such as rural employment effects and concerns around distributional (in)justice. Finally, our results show support for the familiarity effect via temporal exposure for RE sources, though this could also be explained by other trends between 2012 and 2018 such as increasing concern for climate change. We do not find evidence to support the familiarity effect via temporal exposure for nuclear and fracking, for which support is declining despite no major changes in deployment rates.

4.5.2. The effect of demographics

Demographics were found to have a clear effect on people's likelihood of supporting different energy sources in a statistically significant way (at the 5% level). Younger age groups were more likely to support RE (in general), onshore wind, biomass, offshore wind, wave/tidal and solar. This effect was particularly pronounced in the case of onshore wind and offshore wind, with the odds of someone in the 16–24 age group supporting these energy sources on average four times that of someone in the 65+ age group. Older age groups, on the other hand, were more likely to support nuclear and fracking. For example, the odds of someone aged 16–24 being in the support category for nuclear were approximately 20% less than someone aged 65+. This indicates a divergence in preferences for energy sources between age groups.

One explanation for the effect of age on people's attitudes to energy sources is the concept of 'Shifting Baseline Syndrome' (SBS). SBS was originally coined to describe the phenomenon of each generation perceiving the state of ecosystems they encountered in their childhood as normal (Pauly, 1995). It could also describe people's attitudes towards energy sources, although it has received limited application in the field of energy social science to date. An exception to this is Ladenburg and Dubgaard (2007) who find significant differences in attitudes towards offshore wind farms between age groups, with younger people generally more positive than older people. Following Short (2002), they suggest this may be explained by the differences in the 'mental landscape' of different generations: 'older respondents might think of a "pristine" mental landscape which does not include wind turbines. On the other hand, the mental landscape of younger respondents might include wind turbines, because they were already present in the landscape from their past (childhood)' (pp. 4067). Because the younger generations in the PAT dataset have RE technologies as part of their 'baseline', this could explain why they are more likely than older generations to support it.

Our findings around gender again reiterate a difference between those likely to support RE sources, and those likely to support nuclear and fracking. While women were more likely to support all types of RE other than solar, men were more likely to support nuclear and fracking (these results were statistically significant at the 5% level). These findings are in line with other studies' findings (e.g. Corner *et al.*, 2011; van Rijnsoever *et al.*, 2015, Venables *et al.*, 2012; Whitmarsh *et al.*, 2015) and could be explained by differing perceptions of risk. Gender has been found to be an important influence on risk perception, with women tending to be more risk averse (Eckel and Grossman, 2008). Given the various risks associated with fracking and nuclear such as water contamination, earth tremors and nuclear accidents, this may explain why men were more likely to support these energy sources, and women were more likely to oppose them.

In terms of social class, our results support other studies which find higher social class to be associated with greater support for nuclear and hydrocarbons (e.g. Corner *et al.*, 2011; Whitmarsh *et al.*, 2015). This may be because higher levels of education (which are often correlated with higher social class) increases people's awareness of the societal need for energy, or potentially enhances the perception that risks can be handled by technical management solutions. A similar pattern was identified for RE sources, though this effect was quite weak and only statistically significant in a few cases (Figure 12). Social class therefore does not appear to be a strong determinant of support for RE sources.

In summary, our results show that younger age groups and women were more likely to support RE sources, whilst older age groups and men were more likely to support nuclear and fracking. These findings are broadly in line with other studies and support our original hypothesis (Section 4.2.1). Existing studies have somewhat varied findings around gender, meaning that our results help to add clarity to this area. However, our hypothesis was not supported by our results on social class, other than in relation to nuclear and fracking. These energy sources were significantly more likely to be supported by higher social grades than lower social grades (which are used in this study as a proxy for social class). We had predicted that people of higher social classes would be more likely to support *all* energy sources in this study.

4.5.3. Political and economic effects

Our hypothesis on the effect of political orientation was partially supported and partially contradicted by our findings. We predicted that people living in areas with higher levels of representation by the UK Conservative Party were less likely to support RE sources, and more likely to support nuclear and fracking. Our findings, however, show that people living in more politically conservative regions were marginally more likely to support nuclear, onshore wind *and* RE sources (statistically significant at the 5% level). Our results therefore support the literature which finds that conservative political ideology is associated with greater support for nuclear power (e.g. Whitfield *et al.*, 2009), but do not support the literature which finds that conservatism is associated with lower support for RE (e.g. Bidwell, 2013). It should be noted that these conclusions are subject to substantial uncertainty given that we did not have data on the political orientation of individual PAT respondents, only regionally aggregated election data. This analysis could be improved if a more accurate measure of the political orientation of survey respondents were available.

Interestingly, support for all types of energy in the PAT survey was consistently below average in Scotland and London, and frequently in Wales and the North East. This could suggest that being politically isolated from central decision-making bodies (in the case of Scotland and Wales, which historically have a tense relationship with the central UK government in London) influences citizens' likelihood of supporting policies and technologies proposed centrally. On the other hand, people living within London (and therefore theoretically 'close' to centralised institutions) are also below average in terms of support, perhaps because of a lack of familiarity and exposure. Following Batel and Devine-Wright (2018), we recommend further research into how political beliefs interact with public support for energy transitions, particularly given the context of a rise in populism and major political developments such as Brexit which have implications for energy policy and planning.

Similarly, our results also partially support and partially contradict our fourth hypothesis: the effect of employment in the related energy sector on support for energy sources. We expected to find greater levels of support in regions where there is higher employment in the related industry. In support of this hypothesis, we found that people living in areas with higher employment in onshore wind were more likely to support this type of energy source (statistically significant at the 5% level). Our spatial analysis also identified high support for nuclear in rural North West England, where there is historically high employment in this sector (Figure 28 in Supporting Information, Appendix 2). Contrastingly, we found that high employment in the oil and gas sector was associated with *decreased* support for fracking (statistically significant at the 5% level), contrary to our prediction that this would boost support. This could suggest that people who already have oil and gas development in their region do not want even more in the form of fracking, despite potential employment opportunities in the locality.

4.5.4. The effect of environmental beliefs

Of all the independent variables included in our regression modelling, concern for climate change was the strongest and most consistent predictor of support for different energy sources. The odds of people who were very or fairly concerned being in the support or neutral categories for all RE sources were, on average, three times that of those who were not at all concerned about climate change. By contrast, the odds of people who were very concerned about climate change supporting nuclear power and fracking were approximately half of those of people who were not at all concerned. These results were statistically significant at the 5% level. These findings are in line with our predictions and other existing studies in this area (e.g. Hansla *et al*., 2008; Spence *et al*., 2010; van Rijnsoever *et al*., 2015; Whitmarsh *et al*., 2015). Our fifth hypothesis on the effect of environmental beliefs was therefore strongly supported by our results.

Importantly, concern for climate change is increasing over time, rising from 63% in 2012 to 71% in 2018 as measured by the PAT (Figure 29 in Supporting Information, Appendix 2). Over this period, support for all RE sources has been increasing, whilst support for nuclear and fracking has been decreasing. This suggests that as concern for climate change continues to increase, and as climate impacts such as floods and heat waves are felt more frequently and severely in Great Britain (CCC, 2017), the already substantial gap between public support for RE and non-RE will continue to grow. Interestingly, although nuclear power is advocated by some stakeholders as a response to climate change given that it produces fewer carbon emissions than fossil fuels, this does not result in higher support for nuclear amongst PAT respondents with greater climate concern. This is presumably due to wider environmental and ethical concerns about nuclear energy, such as the safe disposal of waste and associated risks to future generations.

4.6. Conclusion

In this paper, we have conducted quantitative and spatial analysis of a large national dataset spanning six years: the UK Government's PAT, from July 2012 to April 2018. Informed by the conceptual framework developed by Roddis *et al*. (2018) to investigate community acceptance of RE projects, we identified and collated a range of variables to test what shapes public support for energy sources at a national scale. By utilising this dataset, we addressed gaps in the existing literature of how trends in public support have unfolded across time, space and social groups, rather than at localised case study scales. Our findings thus have broader implications and relevance to national policy and the national governance of low carbon energy transitions. They also help to understand and explain socio-political acceptance of eight different energy sources, thereby adding insights to the literature beyond well-studied technologies.

We find that despite commonly held assumptions that public opposition to energy can be characterised as NIMBYism, the relationship between the amount of energy infrastructure in people's region, as well as the visual impact of this infrastructure, had limited effect on people's support for that energy source. In other words, we did not find a clear link between direct experience of energy developments in a person's region (i.e. at the community level) with their general attitudes towards that type of energy (i.e. at the socio-political level). Whilst we did identify some spatial variation in attitudes across GB, suggesting that geography does play a role to some extent, the strongest predictors of support were demographic characteristics (particularly age and gender), concern for climate change, and time. Our research therefore lends support to other scholars who argue that NIMBYism is not a satisfactory theory for explaining public acceptance (e.g. Burningham, 2000), as well as research suggesting that worldviews and values (which often vary by demographic) may be the most important predictors of attitudes (Sposato and Hampl, 2018) – something it was not possible for us to consider directly using the PAT dataset. Indeed, the relatively low variance explained by our regression models suggests that there are other important predictor variables which we did not include. Analysis at a finer resolution may also help to uncover further and more detailed spatial patterns.

Whilst this paper has focused on the public or 'societal' dimension of socio-political acceptance, there is also a need for continued research on the political and policymaking dimension of this topic, and better integration between these dimensions to understand the broader dynamics of social acceptance of energy sources and transitions as a whole (Blumer *et al*., 2018; Scherhaufer *et al*., 2018). As energy social scientist Maarten Wolsink emphasises, social acceptance can be thought of as a 'bundle of dynamic processes instead of a set of actor positions' (2018, p. 287), meaning that integrated approaches are important to provide a full understanding of this complex social phenomenon. Additionally, we cannot be sure that our findings can be generalised to countries other than GB, meaning that similar research designs using comparable national data would also be valuable for deepening understanding of this topic across multiple contexts.

Importantly, our analysis shows that support for RE sources has substantially increased from 2012 to 2018, whilst support for nuclear and fracking has markedly decreased. As concern for climate change increases (a trend also demonstrated by the PAT), it seems likely that these diverging levels of support for different energy sources will continue to travel in opposite directions. Given that younger people were found to be more likely to support RE sources, and older people were more likely to support non-renewable nuclear and fracking, it seems likely that in the future the public will increasingly favour renewable over non-renewable energy sources, at least at the socio-political level of acceptance i.e. in terms of generalised public attitudes, though not necessarily in terms of community acceptance of specific energy projects. However, it cannot be ruled out that preferences will change as the current younger generation grows older, meaning that continued research in this area is important in order to monitor these trends.

This raises an important issue around the relationship between public and policymakers' attitudes to energy sources, with implications for national governance of low carbon transitions. Whilst the UK Government is backing a nuclear expansion programme and shale gas development through fracking, it has repeatedly cut subsidies for onshore renewable technologies and changed planning regulations making it harder to build renewable energy projects (Barnham, 2017), citing a lack of public acceptance as a rationale (DECC, 2015). This highlights a clear conflict between national policymakers' preferences for the UK's energy future, and the preferences of the public (as measured by the UK Government) i.e. the two 'dimensions' of socio-political acceptance, as theorised by Wüstenhagen *et al.* (2007). If the transition to a low carbon future is to be achieved in a smooth and timely way, and in a way that is acceptable to all stakeholders, it is crucial that these divergent socio-political preferences are somehow aligned. Whether this is achieved through changes to policy and the energy sources that are supported by policymakers, or by targeted campaigns to change public perceptions, there is a clear need for dialogue between stakeholders to bridge this widening gap and to reach consensus on the energy mix that will be used to achieve decarbonisation.

In this context, it becomes increasingly important to have consistent and reliable data to measure trends in attitudes across society. It is critical that there is long-term consistency in the measurement of public attitudes in order to take account of changes in trends over time, and to inform long-term policy development. The PAT is an extremely valuable resource in this regard, making it concerning that BEIS has recently reduced the regularity with which it asks some questions, specifically the questions measuring attitudes on fracking and nuclear (Holder, 2018).

To conclude, there are multiple rationales for policymakers to measure public attitudes towards energy issues, including enhancing the legitimacy of decision-making (instrumental rationale), providing non-expert input to policy decisions (substantive rationale), and increasing democracy (normative rationale) (Wesselink *et al.*, 2011). However, if public attitudes are not seemingly incorporated into decision-making processes, it becomes unclear which of these rationales is being pursued, potentially eroding trust in decision-making institutions and damaging the social license of energy industries to operate if they do not have the backing of the citizenry. Whilst public attitudes are only one of multiple considerations involved in energy policymaking, our findings call on policymakers to be more transparent in justifying decisions to ensure a smooth and rapid low carbon transition that is acceptable to all.

4.7. References

Anderson, B., Böhmelt, T., and Hugh, W. (2017). Public Opinion and Environmental Policy Output: A Cross-National Analysis of Energy Policies in Europe. *Environmental Research Letters*, 12(11), 1–16. http://doi.org/10.1088/1748-9326/10/12/124002.

Apostol, D., Palmer, J., Pasqualetti, M., Smardon, R., and Sullivan, R. (2016). *The Renewable Energy Landscape: Preserving Scenic Values in our Sustainable Future*. (D. Apostol, J. Palmer, M. Pasqualetti, R. Smardon, and R. Sullivan, Eds.). Abingdon, Oxon; New York, NY: Routledge.

Bailey, I., West, J., and Whitehead, I. (2011). Out of Sight but Not out of Mind? Public Perceptions of Wave Energy. *Journal of Environmental Policy and Planning*, 13(2), 139–157. http://doi.org/10.1080/1523908X.2011.573632

Barnham, K. (2017). Challenge Conservatives on energy priorities and cuts to renewables. *The Guardian*. https://www.theguardian.com/environment/2017/may/10/challenge-conservatives-energy-priorities-cuts-renewables (Accessed on 15/02/2018)

Batel, S., and Devine-Wright, P. (2018). Populism, identities and responses to energy infrastructures at different scales in the United Kingdom: A post-Brexit reflection. *Energy Research and Social Science*, 43, 41–47. http://doi.org/10.1016/j.erss.2018.05.011

Bell, J. F., and Dexter, T. (2000). Using ordinal multilevel models to assess the comparability of examinations. *Multilevel Modelling Newsletter*, 12(2), 4–9. https://www.leeds.ac.uk/educol/documents/00001528.htm (Accessed on 15/02/2018)

Bertsch, V., Hyland, M., and Mahony, M. (2017). What drives people's opinions of electricity infrastructure? Empirical evidence from Ireland. *Energy Policy*, 106, 472–497. http://doi.org/10.1016/j.enpol.2017.04.008

Bidwell, D. (2013). The role of values in public beliefs and attitudes towards commercial wind energy. *Energy Policy*, 58, 189–199. http://doi.org/10.1016/j.enpol.2013.03.010

Bishop, I. D. (2002). Determination of Thresholds of Visual Impact: The Case of

Wind Turbines. *Environment and Planning B: Planning and Design*, 29(5), 707–718. http://doi.org/10.1068/b12854

Bishop, I. D., and Miller, D. R. (2007). Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables. *Renewable Energy*, 32, 814–831. http://doi.org/10.1016/j.renene.2006.03.009

Blumer, Y. B., Braunreiter, L., Kachi, A., Lordan-Perret, R., and Oeri, F., (2018). A two-level analysis of public support: Exploring the role of beliefs in opinions about the Swiss energy strategy. *Energy Research and Social Science*, 43, 109-118. https://doi.org/10.1016/j.erss.2018.05.024

Bonett, D., and Wright, T. (2000). Sample size requirements for estimating pearson, kendall and spearman correlations. *Psychometrika*, 65(1), 23–28. https://doi.org/10.1007/BF02294183

Boudet, H., Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C., and Leiserowitz, A. (2014). "Fracking" controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing. *Energy Policy*, 65, 57–67. http://doi.org/10.1016/j.enpol.2013.10.017

Boudet, H. S., Zanocco, C. M., Howe, P. D., and Clarke, C. E. (2018). The Effect of Geographic Proximity to Unconventional Oil and Gas Development on Public Support for Hydraulic Fracturing. *Risk Analysis*. http://doi.org/10.1111/risa.12989

Breiman, L. (1996). Bagging predictors. *Machine Learning*, 24(2), 123–140. http://doi.org/10.1007/BF00058655

CCC (Committee on Climate Change). (2017). UK Climate Change Risk Assessment 2017 Synthesis report. https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf (Accessed on 15/02/2018)

Connelly, R., Gayle, V., and Lambert, P. S. (2016). A review of educational attainment measures for social survey research. *Methodological Innovations*, 9, 1–11. http://doi.org/10.1177/2059799116638001

Corner, A., Venables, D., Spence, A., Poortinga, W., Demski, C., and Pidgeon, N. (2011). Nuclear power , climate change and energy security: Exploring British public attitudes. *Energy Policy*, 39(9), 4823–4833.

http://doi.org/10.1016/j.enpol.2011.06.037

DECC (Department of Energy and Climate Change). (2014). DECC Public Attitudes Tracker survey – Technical note to accompany published datasets. https://www.gov.uk/government/publications/public-attitudes-tracking-survey-wave-9 (Accessed on 15/02/2018)

DECC (Department of Energy and Climate Change). (2015). Statement on ending subsidies for onshore wind. https://www.gov.uk/government/speeches/statement-on-ending-subsidies-for-onshore-wind (Accessed on 15/02/2018)

del Rio, P., and Burguillo, M. (2009). An empirical analysis of the impact of renewable energy deployment on local sustainability. *Renewable and Sustainable Energy Reviews*, 13, 1314–1325. https://doi.org/10.1016/j.rser.2008.08.001

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review. *Beyond Nimbyism: a multidisciplinary investigation of public engagement with renewable energy technologies. Working Paper No. 1.4*. http://www.sed.manchester.ac.uk/research/beyond_nimbyism/ (Accessed on 15/02/2018)

Devine-Wright, P. (2009) Rethinking Nimbyism: the role of place attachment and place identity in explaining place protective action. *Journal of Community and Applied Social Psychology.* 19(6), 426-441. https://doi.org/10.1002/casp.1004

Devine-Wright, P., Batel, S., Aas, O., Sovacool, B., Labelle, M. C., and Ruud, A. (2017). A conceptual framework for understanding the social acceptance of energy infrastructure: Insights from energy storage. *Energy Policy*, 107, 27–31. http://doi.org/10.1016/J.ENPOL.2017.04.020

Drummond, A., Hall, L.C., Sauer, J. D., Palmer, M. A. (2018). Is public awareness and perceived threat of climate change associated with governmental mitigation targets? *Climatic Change*, 149(2), 159-171. https://doi.org/10.1007/s10584-018-2230-2

Eckel, C. C., and Grossman, P. J. (2008). Men, Women and Risk Aversion: Experimental Evidence. In C. R. Plott and V. L. Smith (Eds.), *Handbook of*

Experimental Economics Results (First, Vol. 1, pp. 1061–1073). Oxford: Elsevier. http://doi.org/10.1016/S1574-0722(07)00113-8

Ek, K. (2005). Public and private attitudes towards "green" electricity: the case of Swedish wind power. *Energy Policy*, 33(13), 1677–1689. http://doi.org/10.1016/J.ENPOL.2004.02.005

Fast, S. (2013). Social Acceptance of Renewable Energy: Trends, Concepts, and Geographies. *Geography Compass*, 7(12), 853–866. https://doi.org/10.1111/gec3.12086

Gaede, J., and Rowlands, I. H. (2018). Visualizing social acceptance research: A bibliometric review of the social acceptance literature for energy technology and fuels. *Energy Research and Social Science*, 40, 142–158. http://doi.org/10.1016/J.ERSS.2017.12.006

Hansla, A., Gamble, A., Juliusson, A., and Gärling, T. (2008). Psychological determinants of attitude towards and willingness to pay for green electricity. *Energy Policy*, 36(2), 768–774. http://doi.org/10.1016/J.ENPOL.2007.10.027

He, H., and Garcia, E. A. (2009). Learning from imbalanced data. *IEEE Transactions on Knowledge and Data Engineering*, 21(9), 1263–1284. http://doi.org/10.1109/TKDE.2008.239

Holder, M. (2018, August 16). BEIS scales back public opinion research on fracking. *Business Green*. https://www.businessgreen.com/bg/news/3061239/beis-scales-back-public-opinion-research-on-fracking (Accessed on 15/02/2018)

Intergovernmental Panel on Climate Change (IPCC). (2018). Global Warming of 1.5°C: Summary for Policymakers. http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf (Accessed on 15/02/2018)

Jones, C. R., Orr, B. J., and Eiser, J. R. (2011). When is enough, enough? Identifying predictors of capacity estimates for onshore wind-power development in a region of the UK. *Energy Policy*, 39(8), 4563–4577. http://doi.org/10.1016/j.enpol.2011.04.044

Kalantaridis, C., and Bika, Z. (2006). Local Embeddedness and Rural Entrepreneurship: Case-Study Evidence from Cumbria, England. *Environment and Planning A*, 38(8), 1561–1579. http://doi.org/10.1068/a3834

Klick, H., and Smith, E. (2010). Public understanding of and support for wind power in the United States. *Renewable Energy*, 35(7), 1585–1591. http://doi.org/10.1016/J.RENENE.2009.11.028

Kock, N., and Lynn, G. S. (2012). Lateral Collinearity and Misleading Results in Variance-Based SEM: An Illustration and Recommendations. *Journal of the Association for Information Systems*, 13(7), 546–580. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2152644

Ladenburg, J., and Dubgaard, A. (2007). Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark. *Energy Policy*, 35(8), 4059–4071. http://doi.org/10.1016/j.enpol.2007.01.023

Ladenburg, J., Termansen, M., and Hasler, B. (2013). Assessing acceptability of two onshore wind power development schemes: A test of viewshed effects and the cumulative effects of wind turbines. *Energy*, 54, 45–54. http://doi.org/10.1016/j.energy.2013.02.021

Lambert, H., and Moy, C. (2013). Social Grade Allocation to the 2011 Census. https://www.mrs.org.uk/pdf/Social%20Grade%20Allocation%20for%202011%20Census.pdf (Accessed on 15/02/2018)

Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C., and Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*, 5, 1014-1020. http://doi.org/10.1038/NCLIMATE2728

Lin, W. C., Tsai, C. F., Hu, Y. H., and Jhang, J. S. (2017). Clustering-based undersampling in class-imbalanced data. *Information Sciences*, 409, 17–26. http://doi.org/10.1016/j.ins.2017.05.008

Liu, T. Y. (2009). EasyEnsemble and feature selection for imbalance data sets. *Proceedings - 2009 International Joint Conference on Bioinformatics, Systems Biology and Intelligent Computing*, 517–520. http://doi.org/10.1109/IJCBS.2009.22

Liu, X. Y., Wu, J., and Zhou, Z. H. (2006). Exploratory under-sampling for class-imbalance learning. *Proceedings - IEEE International Conference on Data Mining, ICDM*, 965–969. http://doi.org/10.1109/ICDM.2006.68

Michaud, K., Carlisle, J. E., and Smith, E. (2008). Nimbyism vs. environmentalism in attitudes toward energy development. *Environmental Politics*, 17(1), 20–39.

http://doi.org/10.1080/09644010701811459

Mishra, S. (2017). Handling Imbalanced Data: SMOTE vs . Random Undersampling. *International Research Journal of Engineering and Technology (IRJET)*, 4(8), 317–320. https://irjet.net/archives/V4/i8/IRJET-V4I857.pdf (Accessed on 15/02/2018)

O'Connell, A. A., Goldstein, J., Rogers, H. J., and Peng, C. Y. J. (2008). Multilevel logistic models for dichotomous and ordinal data. In A. A. O'Connell and D. B. McCoach (Eds.), *Multilevel modeling of educational data*. Charlotte, N.C.: IAP.

Pasqualetti, M. J. (2011). Social barriers to renewable energy landscapes. *Geographical Review*, 101(2), 201–223. http://doi.org/10.1111/j.1931-0846.2011.00087.x

Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution*. http://doi.org/10.1016/S0169-5347(00)89171-5

Rand, J. and Hoen, B. (2017). Thirty years of North American wind energy acceptance research: What have we learned? *Energy Research and Social Science,* 29, 135-148. http://dx.doi.org/10.1016/j.erss.2017.05.019

Ribeiro, F., Ferreira, P., Araújo, M., and Braga, A. C. (2018). Modelling perception and attitudes towards renewable energy technologies. *Renewable Energy*, 122, 688–697. http://doi.org/10.1016/j.renene.2018.01.104

Roddis, P., Carver, S., Dallimer, M., Norman, P., and Ziv, G. (2018). The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis. *Applied Energy*, 226, 353–364. http://doi.org/10.1016/j.apenergy.2018.05.087

Scherhaufer, P., Holtinger, S., Salak, B., Schauppenlehner, T., and Schmidt, J., (2018). A participatory integrated assessment of the social acceptance of wind energy. *Energy Research and Social Science*, 45, 164-172. https://doi.org/10.1016/j.erss.2018.06.022

Short, L. (2002). Wind Power and English Landscape Identity. In M. J. Pasqualetti, P. Gipe, and R. W. Righter (Eds.), *Wind Power in View: Energy Landscapes in a Crowded World* (pp. 43–57). San Diego and London: Academic Press.

Sovacool, B. K., Axsen, J., and Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research and Social Science*, 45, 12-42. https://doi.org/10.1016/j.erss.2018.07.007

Spence, A., Poortinga, W., Pidgeon, N. F., and Lorenzoni, I. (2010). Public perceptions of energy choices: the influence of beliefs about climate change and the environment. *Energy and Environment*, 21(5), 385–407. http://doi.org/10.1260/0958-305X.21.5.385

Sposato, R. G., and Hampl, N. (2018). Worldviews as predictors of wind and solar energy support in Austria: Bridging social acceptance and risk perception research. *Energy Research and Social Science*, 42, 237-246. https://doi.org/10.1016/j.erss.2018.03.012

Stokes, L. C., and Warshaw, C. (2017). Renewable energy policy design and framing influence public support in the United States, *Nature Energy*, 2 (17107), 1–6. http://doi.org/10.1038/nenergy.2017.107

Suna, D. and Resch, G. (2016). Is nuclear economical in comparison to renewables? *Energy Policy*, 98, 199-209. https://doi.org/10.1016/j.enpol.2016.08.023

Swofford, J., and Slattery, M. (2010). Public attitudes of wind energy in Texas: Local communities in close proximity to wind farms and their effect on decision-making. *Energy Policy*, 38(5), 2508–2519. http://doi.org/10.1016/j.enpol.2009.12.046

Tang, Y., and Zhang, Y.-Q. (2006). Granular SVM with Repetitive Undersampling for Highly Imbalanced Protein Homology Prediction. In *IEEE International Conference on Granular Computing*, 457–460. http://doi.org/10.1109/GRC.2006.1635839

Todeschini, G. (2017). Review of Tidal Lagoon Technology and Opportunities for Integration within the UK Energy System, *Inventions*, 1–21. http://doi.org/10.3390/inventions2030014

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5), 2705–2714. http://doi.org/10.1016/j.enpol.2006.12.012

van Rijnsoever, F. J., van Mossel, A., and Broecks, K. P. F. (2015). Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews*, 45, 817–829. http://doi.org/10.1016/j.rser.2015.02.040

Venables, D., Pidgeon, N. F., Parkhill, K. A., Henwood, K. L., and Simmons, P. (2012). Living with nuclear power: Sense of place, proximity, and risk perceptions in local host communities. *Journal of Environmental Psychology*, 32(4), 371–383. http://doi.org/10.1016/J.JENVP.2012.06.003

Warren, C. R., and Birnie, R. V. (2009). Re-powering Scotland: Wind farms and the "energy or environment?" debate. *Scottish Geographical Journal*, 125(2), 97–126. http://doi.org/10.1080/14702540802712502

Warren, C. R., Lumsden, C., O'Dowd, S., and Birnie, R. V. (2005). "Green On Green": Public perceptions of wind power in Scotland and Ireland. *Journal of Environmental Planning and Management*, 48, 853–875. http://doi.org/10.1080/09640560500294376

Wesselink, A., Paavola, J., Fritsch, O., and Renn, O. (2011). Rationales for public participation in environmental policy and governance: Practitioners' perspectives. *Environment and Planning A*, 43(11), 2688–2704. http://doi.org/10.1068/a44161

Whitfield, S. C., Rosa, E. A., Dan, A., and Dietz, T. (2009). The future of nuclear power: Value orientations and risk perception. *Risk Analysis*, 29(3), 425–437. http://doi.org/10.1111/j.1539-6924.2008.01155.x

Whitmarsh, L., Nash, N., Upham, P., Lloyd, A., Verdon, J. P., and Kendall, J.-M. (2015). UK public perceptions of shale gas hydraulic fracturing: The role of audience, message and contextual factors on risk perceptions and policy support. *Applied Energy*, 160, 419–430. http://doi.org/10.1016/j.apenergy.2015.09.004

Williams, R. (2006). Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata Journal*, 6(1), 58–82. http://doi.org/st0097

Williams, R. (2016). Understanding and interpreting generalized ordered logit models. *The Journal of Mathematical Sociology*, 40(1), 7–20. http://doi.org/10.1080/0022250X.2015.1112384

Wilson, G. A., and Dyke, S. L. (2016). Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land Use Policy*, 52, 287–296. http://doi.org/10.1016/j.landusepol.2015.12.008

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy*, 21(1), 49–64. http://doi.org/10.1016/S0960-1481(99)00130-5

Wolsink, M. (2018). Social acceptance revisited: gaps, questionable trends, and an auspicious perspective. *Energy Research and Social Science*, 46, 287–295. http://doi.org/10.1016/j.erss.2018.07.034

Wüstenhagen, R., Wolsink, M., and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. http://doi.org/10.1016/J.ENPOL.2006.12.001

5. What shapes community acceptance of large-scale solar farms? A case study of the UK's first 'nationally significant' solar farm

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5.1. Abstract

New RE infrastructure is essential to deliver net zero policies in response to climate change, but a lack of community acceptance is a potential barrier. It is therefore important to understand what shapes community acceptance and identify policy responses. This paper presents a case study of community acceptance of a large-scale solar farm in the UK, the first to be classified as an NSIP. In doing so, it provides the first empirical study of community acceptance of a large-scale solar farm in a developed country context, building on existing studies which use hypothetical approaches such as choice experiments, or surveys which measure general attitudes rather than responses to specific developments. The paper uses mixed methods (quantitative content analysis of online comments on the planning proposal; qualitative semi-structured interviews with local residents and key stakeholders; and participant observation) to identify determinants shaping community acceptance of large-scale solar farms. We discover 28 determinants which we group into eight categories: aesthetic, environmental, economic, project details, temporal, social, construction and process. We argue that these findings help to reveal broader issues underlying community acceptance of solar farms and other RE infrastructure: 'green-on-green' tensions; issues of scale and place attachment; policy, process and justice. We also contribute a novel understanding of community acceptance as 'relational', by which we mean it is informed by the deployment of other energy technologies and the wider energy policy landscape, not just the specific project. We conclude with recommendations for how policymakers can respond to the issues identified by this article.

5.2. Introduction

Large-scale solar farms are increasingly being built around the world to generate RE. These are ground-mounted arrays of solar PV panels which convert sunlight into electricity, sometimes called solar parks or solar fields. Whilst having advantages in terms of meeting rising energy demand and decarbonising electricity supplies (Sharma, 2011), some solar farm developments have provoked strong negative public reactions. However, the reasons underlying this have not been well explored in academic literature. This paper explores the issues surrounding public acceptance of a large-scale solar farm project in the UK. It is the first solar farm to be classified as an Nationally Significant Infrastructure Project (NSIP), which is the way the planning system in England and Wales deals with major infrastructure that fulfils a national need (Rydin *et al*., 2018). This is a timely topic of research as a growing number of large-scale solar farms are being proposed, driven by low carbon transition policies to meet net zero emissions targets in response to climate change.

We draw upon the influential framework by Wüstenhagen *et al*. (2007) which distinguishes between three dimensions of social acceptance: socio-political, community and market. Socio-political acceptance refers to general support for a technology or policy from the public, policymakers or other actors; community acceptance refers to responses to specific infrastructure projects or proposals by local publics or wider 'communities of relevance' (Batel, 2018); market acceptance refers to the process of market adoption of technologies or innovations by consumers (e.g. the public) or investors. Whilst each are enacted and shaped by various actors, we focus on the role of the public as a key stakeholder across multiple dimensions of social acceptance (Walker, 1995; Boudet, 2019). Though each dimension is fundamental in the implementation of energy innovations (Wolsink, 2018), we focus on community acceptance as a particularly important consideration at the deployment stage because government officials and companies must negotiate with local people (and broader communities of interest) through planning processes (Carley *et al*., 2020). Without community acceptance, it may not be possible to roll-out an innovation, despite acceptance in the socio-political and market realms. In some cases, this can have wider ramifications such as in the case of onshore wind in the UK, for which government subsidies were removed as a result of local backlash (Cowell, 2017). Thus, community acceptance is commonly recognised as a critical factor in the successful implementation of RE policies (Devine-Wright, 2009).

To date, there has been limited research on what shapes community acceptance of large-scale solar farms. This is important because their high land-take and potential conflict with other land uses gives rise to a unique set of environmental, social and economic issues (Jones *et al*., 2015), which are not necessarily directly comparable to more frequently studied technologies such as onshore wind. Against this backdrop, this paper asks the following research questions: *What are the key determinants shaping community acceptance of large-scale solar farms? What does this reveal about broader issues underlying community acceptance of RE infrastructure? How can these issues be better addressed by policymakers?* The paper is structured as follows. In the following section, we review existing academic literature on community acceptance of solar farms and outline our research gap. We then introduce our case study and the mixed (quantitative and qualitative) methods used to address our research questions. Next, we present our results and discuss the broader significance of our findings. In the final section, we offer key academic and policy conclusions and suggest directions for further research.

5.3. Literature review

Solar farms as conceived in this paper are distinguished from Concentrated Solar Power (CSP) plants which use mirrors to direct sunlight onto a small area to generate thermal energy. They are also distinguished from PV installations on rooftops or on water i.e. 'floating' solar farms. Existing solar farms range from small arrays with an output less than 1 MW to 'mega-projects' covering thousands of hectares with an output of 2,000 MW; the largest projects are in China, India and Mexico in semi-arid and desert landscapes (Wolfe, 2019). They are also increasingly developed in densely populated areas such as in Europe, on agricultural and brownfield land. To date, however, research has overlooked public responses to solar farms in these settings.

Yenneti and Day (2015) and Yenneti *et al*. (2016) focus on the case study of Charanka Solar Park in Gujarat, India: one of the largest solar farms in the world. Through stakeholder interviews, they find that some local residents have been dispossessed of resources in the land acquisition process for the project, threatening livelihoods and exacerbating vulnerabilities. Nkoana (2018) identifies corruption and inadequate consultation in the planning process surrounding two solar parks in Limpopo, South Africa, thereby "leaving room for powerful stakeholders to thrive over vulnerable community members" (p34). Issues surrounding livelihoods, access to land, community consultation and fair process thus appear likely to shape community acceptance of solar farms, though it is unclear whether this is specific to developing countries with higher levels of subsistence living and with weaker institutional governance. However, similar issues have been identified in developed countries in relation to other types of energy infrastructure such as oil and gas in Canada (Garvie and Shaw, 2014), onshore wind farms in Australia (Gross, 2007) and marine RE in Ireland (Reilly *et al*., 2016).

Another notable body of solar farm research focuses on the US. For example, Carlisle *et al*. (2014) investigate predictors of support for large-scale solar farms in California, finding that the prospect of positive impacts, such as jobs, had a stronger effect on attitudes than potential negative impacts, such as construction traffic. Carlisle *et al*. (2015) explore whether attitudes vary between a national US sample and a sample in the Southwest: a key area for solar farm development. They find that support is similar across these samples: 82% nationally and 80% in the Southwest, varying slightly according to demographic characteristics. This indicates that public opinion is generally favourable and that direct experience of solar farms has a limited effect. This corresponds with research on wind energy finding that direct experience can in fact lead to increased support, suggesting an 'Inverse NIMBY' (Not In My Back Yard) syndrome (Warren *et al*., 2005). Carlisle *et al*.

(2016) identify high support for solar farms in Southern California, though find that visual impacts and buffer distances can alter people's attitudes.

Whilst useful in identifying broad trends in public attitudes towards solar farms and key factors influencing this (e.g. jobs, visual impacts, buffer distances), these studies are limited in that they do not focus on empirical solar farms. Thus, they are not rooted in a specific context or place, which research shows to be fundamental to community responses to energy infrastructure as a result of issues around place attachment (i.e. connection to the local area) and place identity (Devine-Wright, 2009). Studies which use hypothetical projects to explore community acceptance are limited for similar reasons. For example, Yang *et al*. (2017) conducted a choice experiment in South Korea in which respondents chose between imagined solar farms with differing traits. They found a greater willingness to pay for policies to reduce light pollution, habitat loss, hazardous materials and landscape destruction, the precise amount varying between these impacts (in descending order). Such studies can be influenced by hypothetical bias, in which respondents state how they think they would feel in a given situation, rather than reporting on how they actually experience it (Loomis, 2011). Thus, there remains a research gap on determinants shaping actual community responses to solar farms, which is important as public support has been found to shift when people are asked to think concretely rather than abstractly about the impacts of solar energy projects (Sütterlin and Siegrist, 2017).

Though not focusing on one empirical case, Roddis *et al.* (2018) provide a first attempt at understanding community acceptance of solar farms in a densely populated, developed country. They analyse planning applications for solar farms in GB to identify types of project that are more or less likely to gain planning approval. They find that solar farms proposed on the highest quality agricultural land are on average five times less likely to be approved than those on non-agricultural land. This reflects planning guidance to protect the 'best and most versatile agricultural land' (NPPF, 2012) but may also reflect community opposition to solar farms perceived to conflict with traditional land uses such as farming. This has parallels with existing research on high voltage power lines finding that the 'fit' of energy infrastructure with the landscape shapes community responses (Devine-Wright and Batel, 2013), and indeed may be even more pronounced for solar farms given their higher land-take.

Roddis *et al*. (2018) also find that solar farms are 15% more likely to be approved in more socially and economically deprived areas, raising issues of distributive justice (i.e. the distribution of costs and benefits across society) and procedural justice (i.e. fair and representative decision-making processes) of RE (Heffron and McCauley, 2017). Perceived injustices can in turn have an effect on public perceptions of energy infrastructure (Tabi and Wüstenhagen 2017), highlighting the importance of attending to justice issues when considering public acceptance. Indeed, issues of justice are identified as important for community acceptance of other energy infrastructure such as onshore wind (Simcock, 2016) and shale gas (Cotton, 2017). Finally, Roddis *et al*. (2018) find that smaller solar farms are more likely to be approved than larger ones, indicating that scale is another potentially important issue shaping community acceptance. This would support suggestions from scholars that large-scale infrastructures are more likely to face opposition from the public (Batel *et al*., 2013).

5.4. Case study and methods

5.4.1. Cleve Hill Solar Park

Cleve Hill Solar Park (henceforth referred to as Cleve Hill) was proposed in 2018 in Kent, South East England, and received planning consent in May 2020. It is the first solar farm to be classified as an NSIP, which is how the planning regime in England and Wales deals with major infrastructure developments such as energy, transport and water projects, as established by the Planning Act 2008 (Lee *et al.*, 2013). All onshore energy projects with a capacity above 50 MW are classified as NSIPs, as well as offshore energy projects with a capacity above 100 MW (Natarajan *et al.*, 2018). Cleve Hill has a proposed capacity of 350 MW, making it the second largest solar farm application in GB to date and the third largest application in Europe (following Pizarro in Spain). In line with the NSIP threshold, this paper defines 'large-scale' as solar farms with capacities greater than 50 MW. In GB, there are currently around 1,000 operational solar farms and the average installed capacity is around 8 MW (Roddis *et al.*, 2018).

The average capacity of British solar farms has been increasing in recent years, particularly following changes to the UK Government's subsidy regime in 2015/2016 which substantially lowered Feed-In Tariff rates and closed the Renewables Obligation (the main subsidy scheme at the time) to new solar PV capacity (Burke, 2015). This resulted in a marked drop in the number of planning applications in 2016 (Figure 13). This makes public acceptance of large-scale solar farms a timely topic of research as proposals for large subsidy-free projects such as Cleve Hill come forward which rely on economies of scale to make them financially viable. Two further solar farm NSIPs have submitted planning applications since Cleve Hill: Little Crow Solar Park (150 MW) in December 2018 and Sunnica Energy Farm (500 MW) in March 2019, seemingly indicating this growing trend. Thus, Cleve Hill acts as an "instrumental" case study from which insights can be drawn into the issues surrounding community acceptance of large-scale solar farms more broadly, whilst recognising the specifics of the case (Stake, 1995).

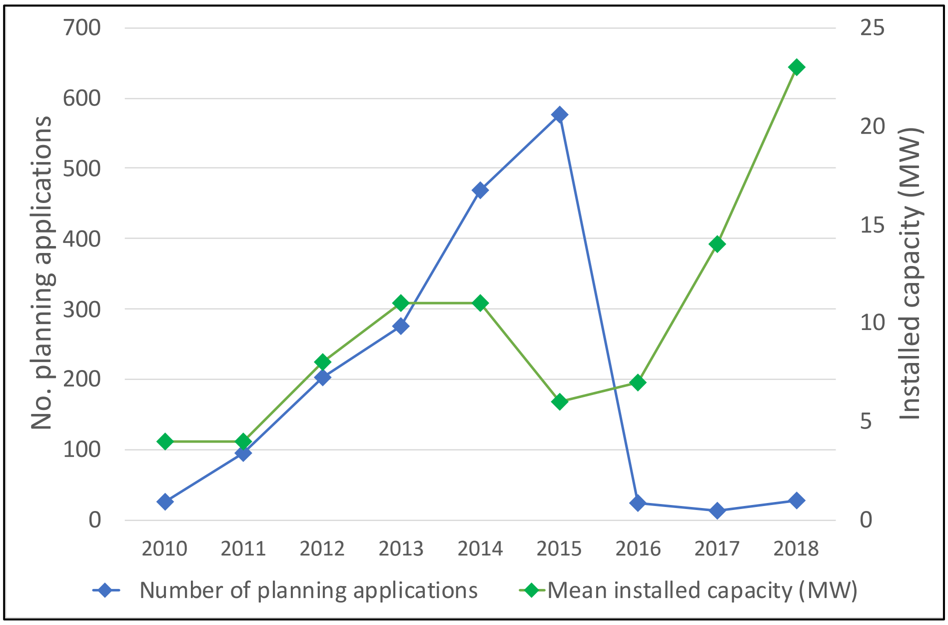

Figure 13. Planning applications for solar farms in GB (150kw+) from 2010 to 2018. Blue markers show total annual number of planning applications (left Y axis); green markers show annual average (mean) installed capacity of installations (right Y axis). Data is from the UK REPD (monthly extract December 2019). NB. Subsidies for solar farms were reduced by the UK Government in 2016, resulting in a fall in applications.

Cleve Hill is a joint venture between two private companies, Hive Energy Limited and Wirsol Energy Limited. The development includes around 1 million solar PV panels along with a battery storage facility, covering a total area of around 1,000 acres (Arcus Consulting, 2017). The land is currently used for arable farming and is classified as 'moderate quality', with an Agricultural Land Classification of 3b (Arcus Consulting, 2017). The land is reclaimed saltmarsh, lending the name Graveney Marshes to the area. The site is bordered to the north by the Swale channel; to the east by a main road and substation infrastructure; to the south by dispersed residential properties; and to the west by the Faversham Creek tidal estuary (Figure 14). There are a number of designated habitats and nature reserves close to the site though not directly overlapping with it, including a Site of Special Scientific Interest (SSSI), Special Protection Area (SPA) and Ramsar wetland site. It is adjacent to or overlapping a number of public footpaths such as the Saxon Shore Way. The site is low lying and prone to flooding. Unlike other British solar farms which are south-facing, the panels are proposed in a novel east-west design to maximise their number and thus electricity generating potential.

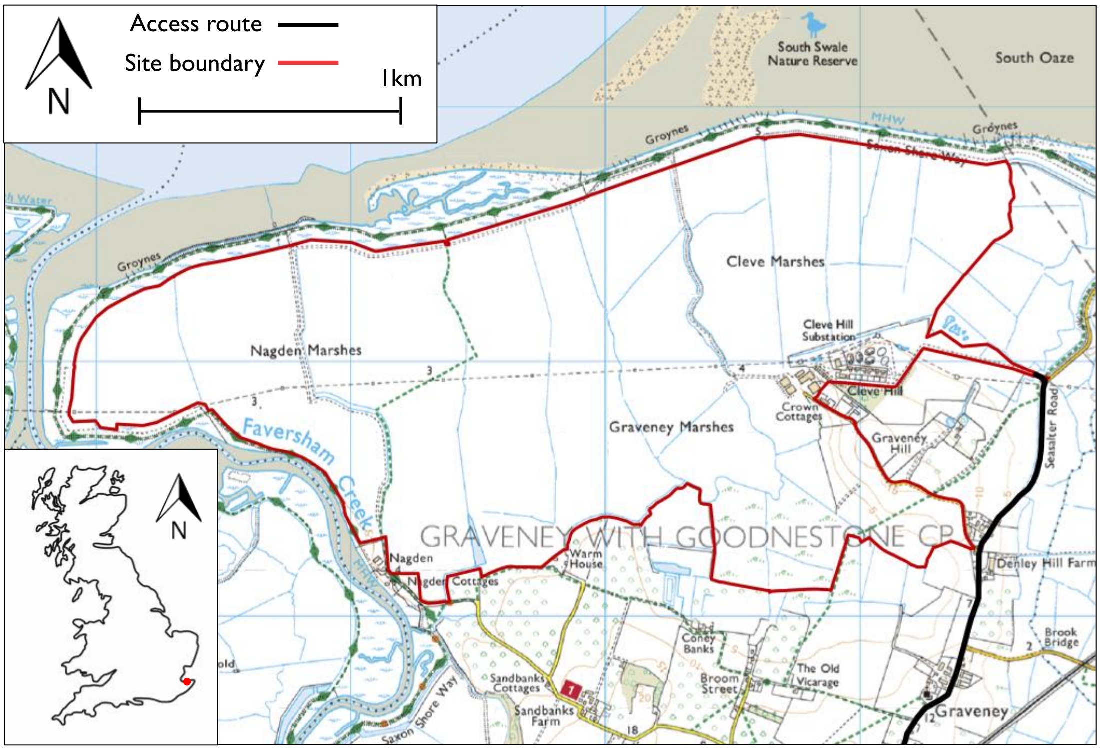

Figure 14. Map of Cleve Hill Solar Park site. Insert shows approximate location in Great Britain (red dot). Image adapted from Scoping Report (Arcus Consulting, 2017), reproduced from Ordnance Survey digital map data. Crown copyright and database rights 2017 Ordnance Survey.

The Cleve Hill project is located in the Swale Local Authority District (LAD) on the north coast of Kent, near the rural village of Graveney (population ~500) and the historic market town of Faversham (population ~19,000) (ONS, 2016). The Swale is a popular tourist and retirement destination with a higher percentage of retired people than the English average (15.1% vs 13.7%) (ONS, 2016). It is a relatively deprived district, ranked 69 out of 317 LADs (IMD, 2019), though there is substantial diversity in terms of affluence within the LAD. There is no community ownership or community benefit scheme attached to the development.

Cleve Hill's proposal sparked substantial debate within the local community about the pros and cons of solar farms, leading to the formation of a local opposition group 'Save Graveney Marshes'. It therefore makes an interesting case study as public acceptance has become a significant issue surrounding the project. All documentation for NSIPs is publicly available online, making these types of projects good case studies in terms of data availability. As an NSIP, Cleve Hill is also a useful case study to explore issues surrounding scale and governance as the planning process is managed centrally by a government body, The Planning Inspectorate, thereby introducing a possible tension between local impacts and national need (as well as the wider global climate benefits of RE).

5.4.2. Methods

To address our research questions, we used both quantitative and qualitative methods. Quantitatively, we carried out content analysis of online comments written by members of the public in response to the Cleve Hill planning proposal (n = 816). These were obtained from the 'Relevant Representations' section of the National Infrastructure Planning website. Qualitatively, we conducted semi-structured interviews with members of the public living near the proposed site and other key stakeholders i.e. planning officials and campaigners (n = 12). We also carried out participant observation at three public hearings and an official site inspection held by The Planning Inspectorate. Our observations allowed us to gain deeper insights into the local context, thus helping to interpret the online comments and interviews.

Online comments (or 'representations') were submitted between December 2018 and January 2019. Statutory and non-statutory authorities and businesses were also able to submit representations; however, we focus on comments made by members of the public to directly address our research questions. Only one comment is allowed per person, though it is allowable to make a comment on someone else's behalf if specified. The Planning Inspectorate requests that comments focus on the aspects of an application a person agrees and/or disagrees with and their reasons why. They ask not to receive comments on issues surrounding compulsory acquisition of land or rights over land, or the merits of a policy set out in a National Policy Statement (which underpin the NSIP regime). There is no word limit though they do request that comments focus on key points and do not allow attachments. This may mean that not all determinants shaping community acceptance are captured in this dataset as people may exclude certain concerns, prioritise the issues they raise or tailor their comments towards what they think will have most traction in the formal planning process.

To identify determinants which *are* captured by this dataset, we drew upon the conceptual framework by Roddis *et al*. (2018) on community acceptance of onshore wind and solar farms. This is the only community acceptance framework the authors are aware of which focuses explicitly on solar farms. We followed an 'abductive' research approach whereby a conceptual framework is applied with a view to modifying it and thus developing new theory (Bryman, 2012). We therefore used the Roddis *et al*. (2018) framework as the basis for developing a coding scheme, adding new codes where we identified determinants not captured by the original framework. As recommended by White and Marsh (2006), where the coding scheme was modified during the coding process it was then re-applied to the data already coded to ensure consistency. We used the data analysis software Nvivo to carry out the coding process.

To select interviewees, a purposive sampling approach was taken whereby key stakeholder groups were identified and targeted (Palinkas *et al*., 2015). Interviewees can be categorised into four groups: active residents (who actively engaged with the planning process for Cleve Hill e.g. by submitting online comments and/or attending public hearings); passive residents (who did not engage with planning process for Cleve Hill); campaigners (who were actively involved in the campaign against Cleve Hill); and planning officials (who were professionally involved in the planning process for Cleve Hill). Questions were tailored for each of these groups, however specific topics were asked about consistently to improve comparability e.g. general views on solar farms as a way of generating electricity, specific views on Cleve Hill, relationship with the Cleve Hill site, participation in the Cleve Hill planning process. Interviews followed a semi-structured format to allow flexibility. Interviewees were recruited in a variety of ways: social media; information sheets placed in public spaces; the lead researcher's attendance at public hearings for the Cleve Hill planning proposal; and snowball sampling.

As far as possible, individuals were sampled from different demographic groups (namely gender and age) as well as differing levels of engagement with the planning process to provide a diversity of perspectives and experiences (Table 8). This was informed by the insight that attitudes to solar farms vary across social groups (Carlisle *et al.*, 2015). The interviews took place either in person or by phone, lasting between 30 minutes and an hour. They were held within a four-week period between July and August 2019, coinciding with the examination stage for Cleve Hill. We conducted fieldwork at this time because it enabled an understanding of how the NSIP planning process shaped people's perspectives, as well as the proposal itself. It also meant that awareness of the proposal was high amongst the local community (public consultation having commenced in 2017). The content analysis was carried out prior to the fieldwork to familiarise the research team with the case and key public concerns. We did not find it necessary to further modify the coding scheme subsequent to the fieldwork.

A mixed method multi-strategy approach allowed breadth and depth of analysis, which has been shown to bring greater understanding of a phenomenon than by using individual approaches (Bryman, 2006). We followed a triangulation mixed methods design (Cresswell and Clark, 2007), whereby complimentary yet distinctly different data was gathered and then integrated for interpretation of the research phenomenon (Almalki, 2016). Importantly, the interviews enabled us to capture perspectives of individuals who had not responded to the online consultation, and the participant observation enabled us to contextualise our analysis.

There are limitations to our methods which are important to acknowledge. Firstly, there is likely to be bias in the sample of respondents who submitted online comments. Research shows that people who feel strongly against a proposed project are more likely to engage with the planning process than those who feel support, qualified support or indifference (Bell *et al*., 2005). Therefore, our analysis of determinants is likely to be skewed towards those who feel strongly against Cleve Hill. Secondly, our analysis is limited to the specific time period in which our data were collected i.e. the planning stage. Research shows that community acceptance of energy infrastructure varies across time stages of the project, usually dipping during the planning stage and rising again following construction (Wilson and Dyke, 2011). Thirdly, the number of interviewees is relatively small due to resource constraints (n = 12). However, we feel the interview data provides an important balance to the online comments because people may have limited or tailored their online comments for the purpose of the planning process and/or formulated them to gain greater political legitimacy and avoid being dismissed as self-interested 'NIMBYs' (van der Horst, 2007). Additionally, the interviews reveal perspectives of community members who did not directly engage with the Cleve Hill planning process.

Table 8. Interviewee details including stakeholder type, participation in the Cleve Hill Solar Park planning process and demographic information

Interviewee	Stakeholder	Participation	Demographics
1	Active resident	Online comment	Female, 40-60
2	Active resident	Online comment	Male, 40-60
3	Active resident	Online comment	Male, 40-60
4	Active resident	Online comment and public hearings	Male, 60+
5	Passive resident	None	Female, 40-60
6	Passive resident	None	Female, 40-60
7	Passive resident	None	Male, 20-40
8	Passive resident	None	Female, 20-40
9	Campaigner	Online comment, public hearings and campaigning	Male, 60+
10	Campaigner	Online comment, public hearings and campaigning	Female, 40-60
11	Planning official	Decision maker	Male, 20-40
12	Planning official	Decision maker	Male, 40-60

5.5. Results and discussion

Our content analysis showed that 98% of online comments (*n* = 803) were opposed to the Cleve Hill proposal and 2% were in favour (*n* = 13). This does not necessarily mean that 98% of the community is opposed, rather this corresponds with other research finding that people who feel strongly against a proposal are often most likely to engage with planning processes (Bell *et al*., 2005). Across the 816 comments, we identified 28 codes (i.e. determinants) which collectively recurred a total of 3776 times. Eighteen of these were identified by our analysis; ten were from the original framework by Roddis *et al*. (2018). We classified these codes into eight categories: aesthetic, environmental, economic, project details, temporal, social, construction and process. The first five of these categories are from Roddis *et al*.

(2018); the latter three were identified by our analysis thus adding to the original framework. We did not identify determinants in the demographic, political or geographical categories of the original framework as this data is either not collected or made available by The Planning Inspectorate. The breakdown of codes within each category is shown in Figure 15 and the breakdown of all codes is shown in Figure 16. Our full coding scheme is shown in Figure 17 and a more detailed description of what each code refers to is provided in Table 15 in Appendix 3.

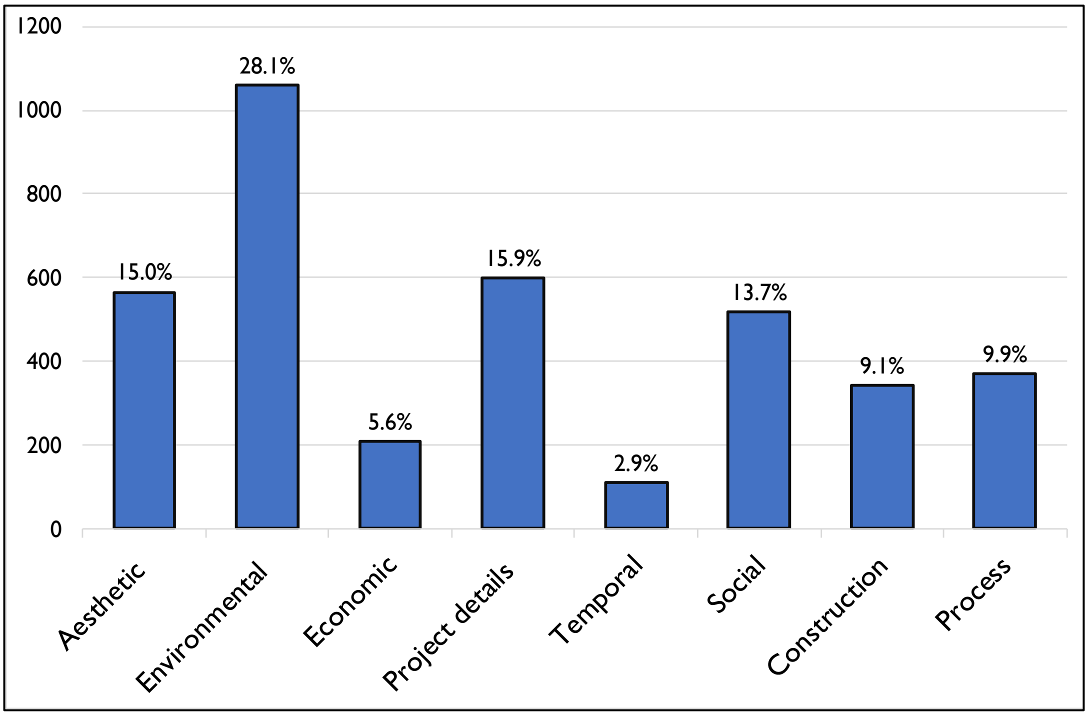

Figure 15. Frequencies and percentages of codes (i.e. determinants of community acceptance) in each category of our coding scheme for analysing online comments from the public on the Cleve Hill Solar Park planning proposal.

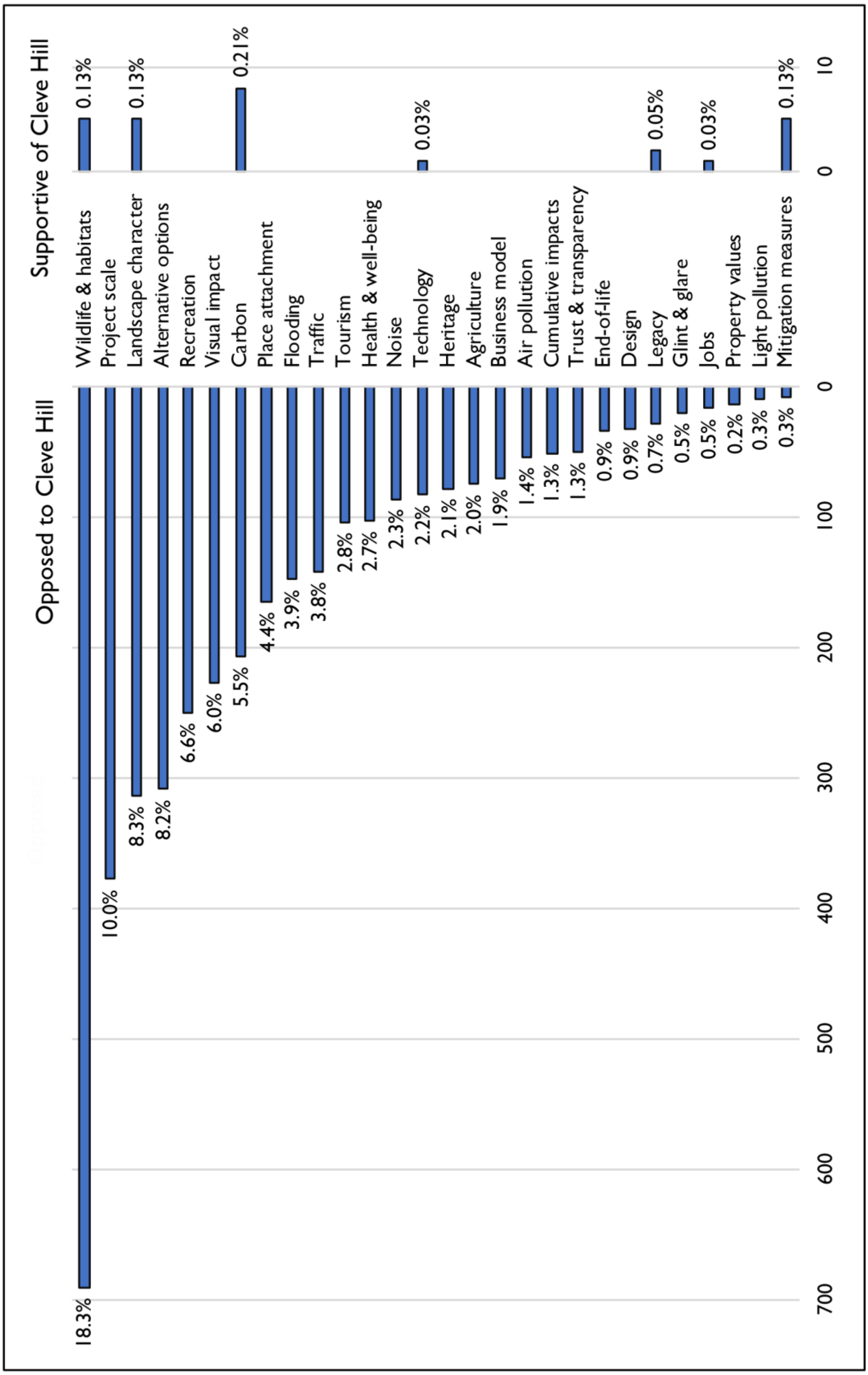

Figure 16. Frequencies and percentages of codes (n = 3776) in each of the 28 sub-codes in our coding scheme for analysing determinants of community acceptance of Cleve Hill Solar Park

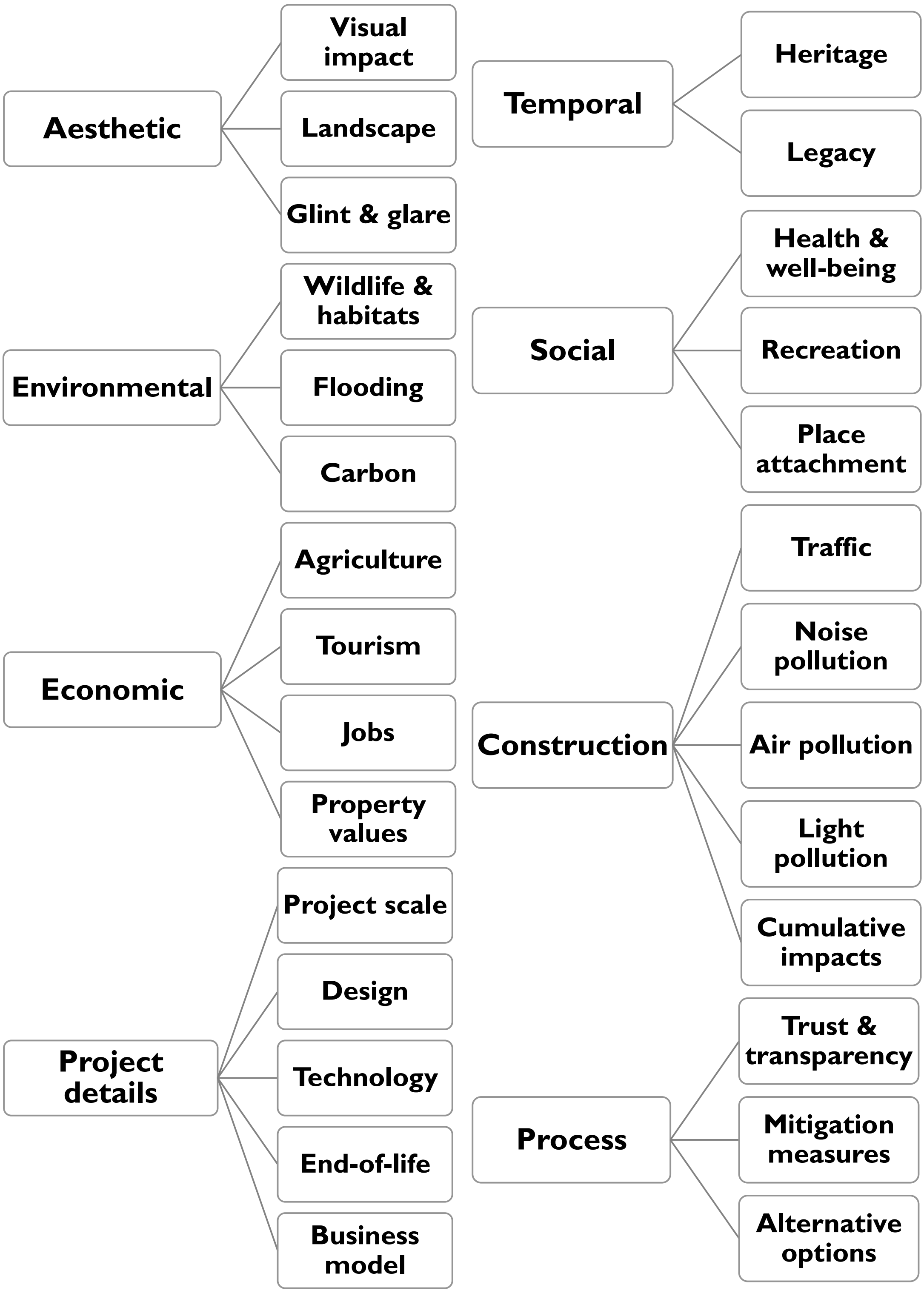

Figure 17. Coding scheme developed in this paper for analysing online comments made by the public on the Cleve Hill Solar Park planning proposal in order to identify the determinants of community acceptance of large-scale solar farms. The aesthetic, environmental, economic, project details and temporal categories are from the conceptual framework by Roddis *et al*. (2018); the social, construction and process categories were added by this paper. 18 of the 28 codes (i.e. determinants) were identified in this paper; 10 are from the original framework.

5.5.1. Green-on-green tensions

Our quantitative results show that the most commonly articulated concern regarding Cleve Hill was its potential impacts on wildlife and habitats, accounting for approximately 18% of all 3776 codes. Of particular concern was potential impacts on birds, which accounted for 51% of all codes on wildlife and habitats. This highlights the 'green-on-green' character of community acceptance of solar farms, whereby measures to mitigate climate change come into conflict with other environmental priorities such as wildlife conservation (Warren *et al*., 2005). This tension is particularly pronounced for Cleve Hill as the site is close to several protected areas for biodiversity and hosts charismatic species such as the Marsh Harrier. Similar concerns have been identified in relation to other RE infrastructure such as wind turbines (e.g. Devlin, 2005); the key difference with solar farms is that the scientific evidence on biodiversity impacts is still evolving meaning there is higher uncertainty (Randle-Boggis *et al*., 2020), particularly for solar farms the size of Cleve Hill and those with an east-west design. This means that *perception* of impacts is a particularly important issue in this context, as well as *known* impacts.

Interestingly, although very few online comments were in favour of Cleve Hill, wildlife was also one of the most frequent codes in support of the project. Specifically, these comments highlighted the creation of a wildlife habitat area adjacent to the facility which was perceived very positively by those who mentioned it. Concern for wildlife was also a common theme across interviewees who supported the project. For instance, interviewee 7 commented:

> *"We have so little time to deal with climate change. Anything that has to happen, it has to happen now [...] As long as you don't wipe out ecosystems, you can still walk around and still see birds, that doesn't bother me that much because psychologically you know why they're there, and they're there to make sure there still is an ecosystem."*

This indicates that biodiversity is a driver both for *and* against solar farms; some people were concerned about the immediate impacts of the infrastructure on wildlife and habitats, whilst others were concerned about the longer-term threat to wildlife posed by climate change. This highlights a temporal dimension to green-on-green conflicts which is often overlooked. It also indicates that the perception of the impacts of solar farms may vary depending on one's concern for climate change.

Other interviewees highlighted the complexity of deciding what actually counts as 'green'. As interviewee 10, a lead campaigner from 'Save Graveney Marshes', expressed:

> *"We all know that we need clean energy and we've got to do something about climate change, but we have to be mindful of the actual environment we're destroying to create that 'clean' energy. You have to look at where those solar panels are coming from, and things like transport, not just the generation of the energy. You have to look at the whole thing to decide whether it's green, and I don't think we can say that is the case here."*

This reveals a sophisticated understanding of the various sustainability metrics for energy, with direct carbon emissions only one of a number of environmental impacts that arise over the lifecycle of energy projects. This demonstrates the complexity of evaluating the 'most' sustainable option when deliberating green-on-green tensions such as large-scale solar farms and other types of RE, given the multiple environmental dimensions at play such as land usage, impact on wildlife and carbon emissions.

Another interesting aspect of the Cleve Hill case study is that it is proposed on land which is prone to flooding and acts as a flood plain. This means that the panels must be raised to avoid flood water, thus adding to the project's visual impact. Climate change makes this elevation all the more necessary due to sea level rise and increased flood risk. Currently, the site's flood risk is managed by the Environment Agency (EA), a statutory body; however, the developer is due to take over this responsibility. The online comments and interviews reflected concern that the developer would prioritise the protection of their infrastructure rather than local residences and businesses. Others raised the point that if the EA continues to manage the site there are plans for coastal realignment whereby the land will be reverted to saltmarsh to help mitigate flooding and enhance carbon sequestration. This exemplifies a complex set of green-on-green tensions which are specific to community acceptance solar farms as opposed to other RE infrastructure such as wind turbines. The amount of land required for solar farms forces consideration of how best to utilise space to meet environmental objectives including carbon reduction, carbon storage, visual amenity, flood management and wildlife conservation. In turn, these must be weighed against the societal need for energy. This accords with other scholars such as Holland *et al*. (2016) and Randle-Boggis *et al*. (2020) who argue that an ES approach to energy planning may be beneficial to evaluate these interactions, and to identify trade-offs that the public and other stakeholders are most (and least) willing to accept. In some cases, it may be that solar farms could in fact improve ES provision for example by planting wildflowers in the margins of solar farm developments (Randle-Boggis *et al*., 2020).

5.5.2. Issues of scale and place attachment

The code that appeared in the online comments most frequently after wildlife and habitats was the scale of the project, accounting for 10% of codes. This included references to the land area of the site (roughly equivalent to 750 football fields), the height of the panels (raised to 3.9m to avoid flood water) and the generating capacity (350 MW). It was commonly described as a "*megaproject*" and comments relating to the scale were framed in a pejorative way such as "*ridiculously enormous*", "*very intrusive height and expanse*" and "*far too big for such a small area of Kent*". This raises an interesting dynamic between the relative scale of the project and the space it occupies, similar to the finding that the 'fit' of energy infrastructure in the landscape shapes community responses (Devine-Wright and Batel, 2013; Devine-Wright and Wiersma, 2020). The comparable area of the site to Faversham was also frequently highlighted by interviewees, emphasising that a project of this size was not seen to 'fit' with the local area. These findings also show the influence of the Save Graveney Marshes campaign on people's responses (Figure 18), indicating the socially constructed nature of community acceptance i.e. people do not form their views in isolation, but also take cues from their peers and those around them (Devine-Wright, 2007).

Figure 18. 'Save Graveney Marshes' campaign posters on a board overlooking the proposed site for Cleve Hill Solar Park, one reading: 'No to the solar park! As big as Faversham' and the other highlighting landscape impacts. Photograph was taken by the lead researcher in July 2019.

One explanation for the negative responses to the scale of the project is that it emphasises the change in the traditional use of the landscape. Indeed, the third most frequent code was landscape character. England is a fairly settled landscape, meaning that people are accustomed to the landscape being the way that it currently is (Selman, 2010). New energy infrastructure disrupts this sense of "landscape permanence" and can trigger public opposition (Pasqualetti, 2000). This has been found to be important issue for wind energy and may be even more so for solar farms as they largely preclude the land continuing to be used for other purposes. Thus, they may come to be regarded by the public as a more fundamental change to the landscape than wind turbines. Interestingly however, although the Cleve Hill site is currently agricultural, impacts on agriculture were not identified in the interviews or content analysis as a very strong determinant of community acceptance, representing 2% of codes. Instead, the underlying concerns around the project's scale appear to be more strongly driven by place attachment, as indeed existing research has identified as important for other types of energy infrastructure.

Place attachment refers to the bonding between individuals and their environments (Scannell and Gifford, 2010). In our content analysis, 4.4% of codes explicitly expressed place attachment i.e. they expressed love or strong affection for the Cleve Hill site or wider area. However, many other codes are also intertwined with place attachment, such as landscape character (8.3%), recreation (6.6.%), visual impact (6%), and health and well-being (2.7%). Our interview data also identified place attachment. For example, interviewee 5 commented on the spiritual value of Graveney Marshes and how they were saddened by the prospect of losing a place that they frequently visited and was very special to them:

> *"I love nature. In terms of my faith, I feel close to God when I'm near nature, and we won't have that anymore. It will just be industrial."*

This demonstrates the religious or spiritual importance of the marshes to the community, another important component of place attachment. This finding can be described as a 'cultural ecosystem service' (Fish *et al.*, 2016) i.e. the non-material benefits people obtain from nature, further demonstrating the value of applying an ES approach to public acceptance of RE.

The issues of scale and place attachment discussed here are particularly relevant to NSIPs as they are underpinned by a policy presumption of national need (Johnstone, 2014). Both online respondents and interviewees frequently acknowledged the need for low carbon energy generation, taking into account the national scale (energy supply issues) and the global scale (tackling climate change). However, their views are deeply embedded in the local scale and concerns over the local impacts of the Cleve Hill project. Interviewee 5 described this tension as a "*battle in my head*" because they recognised the broader benefits of the project but were distressed about the loss of a highly valued place in their local area. Similarly, many online respondents stated that they supported solar technology generally because of its low carbon emissions (6% of all codes) but did not support Cleve Hill specifically, demonstrating the multi-scalar character of community acceptance of RE. This supports calls to provide policymakers with more realistic measures of community acceptance to avoid misleading expectations of public responses to solar energy (Sütterlin and Siegrist, 2017). It also supports existing research (e.g. Roberts and Escobar, 2015) which finds that the public deliberate a range of complex issues when formulating their opinions on energy infrastructure, supporting a shift away from simplistic accusations of NIMBYism.

5.5.3. Issues of scale and place attachment

Other key themes arising from our analysis relate to policy, process and the justice implications of these issues. The fourth most frequent code identified in the online comments (8.2%) related to alternative options i.e. the perception that other locations or technologies were more suitable for generating electricity and reducing emissions, frequently accompanied by a perception that these had not been adequately considered by decision-makers. In particular, the topic of rooftop solar was a common theme across the interviews, as well as the online comments: 32.4% of the 'alternative options' codes referred to putting solar on industrial or domestic rooftops. This indicates that community acceptance of solar farms is 'relational' rather than absolute; by this we mean it is informed by the deployment of other energy technologies and the wider energy policy landscape, not only the specific solar farm. This builds on conceptions of community acceptance as 'qualified' or 'conditional' depending on project characteristics or attitudes to the technology (Bell *et al*., 2005; Ellis *et al*., 2007).

This relationship between community acceptance of solar farms and the wider energy policy context is illustrated well by this comment from interviewee 2:

> "*I think there's a big problem in the UK with building regulations and how we use energy. In Faversham, we have around a thousand new homes being built around the town; none have solar panels on the roof or are designed with any idea that you could retrofit because of the way they're*

oriented. It's cheaper and easier to use a greenfield site, but it's using up an environmental space. So it's a case of I'm not against solar farms, but we need a far more grown up and integrated approach to energy in total. It's the lack of a national integrated approach that bothers me."

Similarly, interviewee 8 expressed that their views towards Cleve Hill were intertwined with policy, referring to the UK government's subsidy cuts for rooftop solar (Kabir *et al*., 2018):

> "*I think it would be better if we use space where there are already structures, like if you put solar panels on top of houses then you're utilising the space much better. But if the government aren't going to support that, we haven't really got another option."*

We believe the insights offered by these results are a novel contribution to the literature, showing that community acceptance is not only conditional on the specifics of a project or views towards the specific technology in question (Ellis *et al*. 2007), but is also *relational* i.e. it is deeply intertwined with wider policy context and the context of which other energy technologies are currently being deployed.

In line with extant research on solar farms (e.g. Nkoana, 2018), we also find that consultation processes are a noteworthy consideration. Issues relating to 'trust and transparency' (regarding the developer and the Planning Inspectorate) accounted for 1.3% of codes. For example, online comments described a "*misleading and deceitful public consultation process*" and argued that "*the procedure followed does not offer meaningful consultation and tends therefore to create its own momentum, which is procedurally unjust*". This sentiment was echoed by interviewee 9 who described the process as "*asymmetrical warfare*" because they judged that the developers had greater resources and influence in the planning process than local people. This shows that as well as the project itself and the wider policy context, process surrounding planning for large-scale solar farms can be an important factor shaping community acceptance. This supports other research (e.g. Lee *et al*., 2018; Natarajan *et al*., 2019) which finds that participation in NSIP planning processes should be made more inclusive of the public and community stakeholders.

Other online comments highlighted the privatised business model and lack of community benefits for Cleve Hill (1.9% of codes), commenting there was "*no benefit whatsoever for the local people*". This sentiment also arose in the interview data, for example interviewee 6:

> *"I don't know where the power from this development is going to go, it would be good if it was consumed locally. Where is the profit going? Where is the power going? The people of this area will be looking at the solar panels, but will they have any benefit from it? I think some money should come off the energy bills of the local people."*

This reveals a perception of unfair distribution of costs and benefits i.e. a distributional injustice, as well as the procedural injustice noted in the previous paragraph (Walker, 2009). Another 'cost' is the risk of fire from the battery storage which is a relatively untested technology, accounting for 2.2% of codes (coded under 'technology'). This indicates that unjust distribution of costs, risks and benefits influences community acceptance, supporting existing research which finds that perceptions of injustice shape responses to RE infrastructure (Tabi and Wüstenhagen, 2017). It also adds to calls on the need for a holistic 'just transition' which takes into account the full range of impacts, risks and benefits arising from the transition to a low carbon society (Heffron and McCauley, 2018).

5.6. Conclusions and recommendations

This paper contributes the first empirical study of community acceptance of a large-scale solar farm in a densely populated, developed country context. The key contributions are as follows. Through content analysis of 816 online planning responses, supplemented with 12 qualitative interviews and participant observation, we build on the conceptual framework established by Roddis *et al*. (2018) to describe the key categories of determinants shaping community acceptance of large-scale solar farms: aesthetic, environmental, economic, project details, temporal, social, construction, and process. The latter three categories are identified in this paper and are thus a new contribution towards the existing framework. We also identify 28 determinants of community acceptance within these eight overarching categories, of which 18 are original contributions. Further research could test other frameworks for comparison (e.g. Harper *et al*., 2019) and draw upon different data sources such as social media content, given there are limitations to using planning responses as a measure of community acceptance and our relatively small interview sample size. This type of research could also be repeated at a different stage of the Cleve Hill project's lifespan, as our results focus on the planning stage before the project is actually built.

Another contribution is to highlight the 'green-on-green' character of community acceptance of solar farms. The most frequent concern raised about Cleve Hill in the online consultation was its potential impacts on wildlife and habitats. Whilst there is scientific uncertainty regarding impacts of solar farms on wildlife, particularly in relation to solar farms the size of Cleve Hill and those with an east-west design, it is clear that the *potential* conflict was a major determinant of community (non)acceptance. This indicates that research on the impacts of solar farms on wildlife should be prioritised by policymakers in order to enhance the evidence base and increase certainty. This article also raises many issues about how land is best used to achieve different policy goals including energy generation, wildlife habitat, agriculture, carbon storage and flood mitigation. In the context of low carbon transitions, policymakers may need to more strategically plan how land is going to be used in order to balance these competing goals, potentially drawing upon an ES approach as suggested by other scholars to identify synergies and trade-offs. This may involve prioritising rooftop PV installations or solar farms on brownfield sites to avoid the green-on-green tensions identified in this paper. Despite the UK government's previous policy attempts to encourage developments in these locations (Cowell and Devine-Wright, 2018), lack of subsidies appears to be driving large-scale proposals such as Cleve Hill, perhaps due to the need for economies of scale for viability.

This links closely to another key contribution of this article which is to highlight issues of scale and place attachment as important to community acceptance of solar farms. The scale of the Cleve Hill project was the second most frequent concern identified in the online comments. This connects to many other frequently raised concerns such as landscape character, visual impacts and recreation, all of which are intertwined with place attachment. Issues of scale are particularly important for solar NSIPs because they are designed to fulfil a national need and have global benefits for the climate, but their impacts are experienced locally. Policymakers could address these multi-scalar issues by limiting the area of land that can be used for any one energy development, or by implementing a minimum MW output/per unit of land area. Alternatively, the total area of land used for energy production could be capped through spatially explicit strategic planning.

Finally, we highlight the role of policy and process in shaping community acceptance of solar farms. We find that people's broader views on energy policy feed into their views on specific infrastructure projects such as Cleve Hill, which we describe as a 'relational' understanding of community acceptance. This builds on conceptions of community acceptance as 'conditional' or 'qualified' depending on project characteristics or attitudes to that technology (e.g. Bell *et al*., 2005; Ellis *et al*., 2007). This highlights the need for joined-up energy strategy to meet climate goals which takes account of public acceptance across the whole energy system, not just isolated aspects of it. We also show that consultation processes are an important factor, emphasising the need for developers and The Planning Inspectorate to reconsider their approach to consulting local people and find ways to make this more inclusive. Another policy approach would be to make more use of community benefit funds to compensate host communities for the impacts of solar farms. This would help to more equally distribute the costs and benefits of RE and has the potential to improve perceptions of justice, though should not be regarded as a 'silver bullet' for community acceptance (Cass *et al*., 2010).

Whilst our results are inevitably tied to the Cleve Hill case study, they may provide insights into how communities may respond to other large-scale solar farms. This is particularly topical given the increasing average capacity of solar farms in GB, as well as the rising number of solar farm mega-projects around the world. It may also help to understand acceptance of other RE infrastructure, which is important in the context of climate crisis and policy targets to reach net zero emissions. A key difference between our results and other studies is that potential negative impacts were much more prominent than positive impacts such as jobs, in contrast to Carlisle *et al*. (2014) who found the opposite. In our analysis, the issue of employment featured in only 0.5% of codes. This is perhaps an indication of the difference between research elicited from participants in relation to hypothetical solar farms versus the concerns of communities when faced with the reality of a proposed project. Whilst this may reflect bias in the people who responded to the consultation and the topics which tend to arise through invited consultation in planning processes, it also emphasises the importance of triangulating results from hypothetical studies with empirical data on community acceptance (ideally via multiple methods) to provide policymakers with better evidence to make decisions about the ongoing transition to RE.

5.7. References

Almalki, S. (2016). Integrating Quantitative and Qualitative Data in Mixed Methods Research – Challenges and Benefits. *Journal of Education and Learning*, 5(3): 288–296. https://doi.10.5539/jel.v5n3p288

Arcus Consulting. (2017). Environmental Impact Assessment (EIA) Scoping Report - Cleve Hill Solar Park. https://infrastructure.planninginspectorate.gov.uk/wpcontent/ipc/uploads/projects/EN010085/EN010085-000377-6.4.3.1%20EIA%20Scoping%20Report.pdf (Accessed on 01/08/2019)

Batel, S., Devine-Wright, P., and Tangeland, T. (2013). Social acceptance of low carbon energy and associated infrastructures: A critical discussion. *Energy Policy*, *58*, 1-5. https://doi.org/10.1016/j.enpol.2013.03.018

Batel, S. (2018). A critical discussion of research on the social acceptance of renewable energy generation and associated infrastructures and an agenda for the future. *Journal of Environmental Policy & Planning*, *20*(3), 356-369. https://doi.org/10.1080/1523908X.2017.1417120

Bell, D., Gray, T. and Haggett, C. (2005). The "social gap" in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, 14(4): 460–477. https://doi.org/10.1080/09644010500175833

Boudet, H.S. (2019). Public perceptions of and responses to new energy technologies. *Nature Energy*, 4(6): 446-455. https://doi.org/10.1038/s41560-019-0399-x

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done?', *Qualitative Research*, 6(1): 97–113. https://doi.10.1177/1468794106058877

Bryman, A. (2012). *Social Research Methods 4th edition*. Oxford: Oxford University Press.

Burke M. (2015). Solar farms: funding, planning and impacts. House of Commons Library: Briefing Paper. https://commonslibrary.parliament.uk/research-briefings/cbp-7434/ (Accessed on 01/06/2020)

Carley, S., Konisky, D., Atiq, Z. and Land, N., (2020). Energy infrastructure, NIMBYism, and public opinion: a systematic literature review of three decades of empirical survey literature. *Environmental Research Letters*. 15, 093007. https://doi.org/10.1088/1748-9326/ab875d

Carlisle, J. E., Kane, S., Solan, D. and Joe, J. C. (2014). Support for solar energy: Examining sense of place and utility-scale development in California. *Energy Research and Social Science*, 3, 124–130. https://doi.10.1016/j.erss.2014.07.006

Carlisle, J. E. Kane, S., Solan, D., Bowman, M. and Joe, J. C. (2015). Public attitudes regarding large-scale solar energy development in the US. *Renewable & Sustainable Energy Reviews*, 48: 835–847. https://doi.10.1016/j.rser.2015.04.047

Carlisle, J.E., Solan, D., Kane, S.L. and Joe, J., (2016). Utility-scale solar and public attitudes toward siting: A critical examination of proximity. *Land Use Policy*, *58*, 491-501. https://doi.org/10.1016/j.landusepol.2016.08.006

Cass, N., Walker, G., and Devine-Wright, P. (2010). Good neighbours, public relations and bribes: the politics and perceptions of community benefit provision in renewable energy development in the UK. *Journal of Environmental Policy & Planning*, *12*(3), 255-275. https://doi.org/10.1080/1523908X.2010.509558

Cotton, M. (2017). Fair fracking? Ethics and environmental justice in United Kingdom shale gas policy and planning. *Local Environment*, *22*(2), 185-202. https://doi.org/10.1080/13549839.2016.1186613

Cowell, R. (2017). Decentralising energy governance? Wales, devolution and the politics of energy infrastructure decision-making. *Environment and Planning C: Politics and Space*, 35(7): 1242–1263. https://doi.10.1177/0263774X16629443

Cowell, R. and Devine-Wright, P. (2018). A 'delivery-democracy dilemma'? Mapping and explaining policy change for public engagement with energy infrastructure. *Journal of Environmental Policy & Planning*, 20(4): 499-517. https://doi.org/10.1080/1523908X.2018.1443005

Creswell, J. W. and Plano Clark, V. L. (2007). Designing and Conducting Mixed Methods Research. London: Sage Publications Ltd.

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review. *Beyond Nimbyism: a* *multidisciplinary investigation of public engagement with renewable energy technologies. Working Paper No. 1.4*. http://www.sed.manchester.ac.uk/research/beyond_nimbyism/ (Accessed on 01/09/2019)

Devine-Wright, P. (2009). Rethinking NIMBYism: The Role of Place Attachment and Place Identity in Explaining Place-protective Action. *Journal of Community and Applied Social Pyschology* 19(6): 426–441. https://doi.10.1002/casp.1004

Devine-Wright, P., and Batel, S. (2013). Explaining public preferences for high voltage pylon designs: An empirical study of perceived fit in a rural landscape. *Land Use Policy*, *31*, 640-649. https://doi.org/10.1016/j.landusepol.2012.09.011

Devine-Wright, P., and Wiersma, B. (2020). Understanding community acceptance of a potential offshore wind energy project in different locations: An island-based analysis of 'place-technology fit'. *Energy Policy*, *137*, 111086. https://doi.org/10.1016/j.enpol.2019.111086

Devlin, E. (2005). Factors affecting public acceptance of wind turbines in Sweden. *Wind Engineering*, *29*(6), 503-511. https://doi.org/10.1260/030952405776234580

Ellis, G., Barry, J., and Robinson, C. (2007). Many ways to say "no", different ways to say "yes": Applying Q-Methodology to understand public acceptance of wind farm proposals. *Journal of Environmental Planning and Management*, 50(4), 517–551. http://doi.org/http://dx.doi.org/10.1080/09640560701402075

Fish, R., Church, A., and Winter, M. (2016). Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. *Ecosystem Services*, *21*, 208-217. https://doi.org/10.1016/j.ecoser.2016.09.002

Garvie, K. H., and Shaw, K. (2014). Oil and gas consultation and shale gas development in British Columbia. *BC Studies: The British Columbian Quarterly*, (184), 73-102. https://doi.org/10.14288/bcs.v0i184.184888

Gross, C. (2007). Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance. *Energy policy*, *35*(5), 2727-2736. https://doi.org/10.1016/j.enpol.2006.12.013

Harper, M., Anderson, B., James, P.A. and Bahaj, A.S. (2019). Onshore wind and the likelihood of planning acceptance: Learning from a Great Britain context. *Energy Policy*, 128: 954-966. https://doi.org/10.1016/j.enpol.2019.01.002

Heffron, R. J., and McCauley, D. (2017). The concept of energy justice across the disciplines. *Energy Policy*, *105*, 658-667. https://doi.org/10.1016/j.enpol.2017.03.018

Heffron, R. J., and McCauley, D. (2018). What is the 'just transition'? *Geoforum*, *88*, 74-77. https://doi.org/10.1016/j.geoforum.2017.11.016

Holland, R. A., Scott, K., Hinton, E. D., Austen, M. C., Barrett, J., Beaumont, N., and Taylor, G. (2016). Bridging the gap between energy and the environment. *Energy Policy*, 92, 181–189. https://doi.org/10.1016/j.enpol.2016.01.037

IMD (Index of Multiple Deprivation). (2019). Indices of Deprivation: 2019 and 2015. http://dclgapps.communities.gov.uk/imd/iod_index.html# (Accessed on 01/06/2020)

Johnstone, P. (2014). Planning reform, rescaling, and the construction of the postpolitical: the case of The Planning Act 2008 and nuclear power consultation in the UK. *Environment and Planning C: Politics and Space*, 32(4): 697–713. https://doi.org/10.1068/c1225

Jones, P., Comfort, D. and Hillier, D. (2015). Spotlight on solar farms. *Journal of Public Affairs*, 15(1): 14–21. https://doi.org/10.1002/pa.1482

Kabir, E., Kumar, P., Kumar, S., Adelodun, A. A. and Kim, K. H. (2018). Solar energy: Potential and future prospects. *Renewable and Sustainable Energy Reviews*, 82(1): 894– 900. https://doi.org/10.1016/j.rser.2017.09.094

Lee, M., Armeni, C., Cendra, J., Chaytor, S., Lock, S., Maslin, M., Redgwell, C. and Rydin, Y. (2013). Public Participation and Climate Change Infrastructure. *Journal of Environmental Law,* 25(1): 33–62. https://doi.org/10.1093/jel/eqs027

Lee, M., Lock, S., Natarajan, L., and Rydin, Y. (2018). Decision-making for major renewable energy infrastructure. *Journal of Planning and Environmental Law*, *2018*(5), 507-512. https://discovery.ucl.ac.uk/id/eprint/10045051/ (Accessed on 01/06/2020)

Loomis, J. (2011). What's to know about hypothetical bias in stated preference valuation studies? *Journal of Economic Surveys*, 25(2): 363–370. https://doi.org/10.1111/j.14676419.2010.00675.x

Natarajan, L., Rydin, Y., Lock, S. J. and Lee, M. (2018). Navigating the participatory processes of renewable energy infrastructure regulation: A "local participant perspective" on the NSIPs regime in England and Wales. *Energy Policy*, 114, 201–210. https://doi.org/10.1016/j.enpol.2017.12.006

Natarajan, L., Lock, S. J., Rydin, Y., and Lee, M. (2019). Participatory planning and major infrastructure: experiences in REI NSIP regulation. *Town Planning Review*, *90*(2), 117-138. https://doi.org/10.3828/tpr.2019.10

Nkoana, E. M. (2018). Community acceptance challenges of renewable energy transition: A tale of two solar parks in Limpopo, South Africa. *Journal of Energy in Southern Africa*, 29(1): 34–40. https://doi.org/10.17159/2413-3051/2018/v29i1a2540

NPPF (National Planning Policy Framework). (2012). National Planning Policy Framework'. https://webarchive.nationalarchives.gov.uk/20180608095821/https://www.gov.uk/govern ment/publications/national-planning-policy-framework--2 (Accessed on 01/08/2019)

ONS (Office for National Statistics). (2016). 2011 Census aggregate data. UK Data Service (Edition: June 2016). http://dx.doi.org/10.5257/census/aggregate-2011-1 (Accessed on 01/06/2020)

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., and Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, *42*(5), 533-544. https://doi.10.1007/s10488-013-0528-y

Pasqualetti, M. J. (2000). Morality, Space, and the Power of Wind-Energy Landscapes. *Geographical Review*, *90*(3), 381–394. http://www.jstor.org/stable/3250859

Randle-Boggis, R. J., White, P. C. L., Cruz, J., Parker, G., Montag, H., Scurlock, J. M. O., and Armstrong, A. (2020). Realising co-benefits for natural capital and ecosystem services from solar parks: A co-developed, evidence-based approach. *Renewable and Sustainable Energy Reviews*, *125*, 109775. https://doi.org/10.1016/j.rser.2020.109775

Reilly, K., O'Hagan, A. M., and Dalton, G. (2016). Moving from consultation to participation: A case study of the involvement of fishermen in decisions relating to marine renewable energy projects on the island of Ireland. *Ocean & Coastal Management*, *134*, 30-40. https://doi.org/10.1016/j.ocecoaman.2016.09.030

Roberts, J. and Escobar, O. (2015). Involving communities in deliberation: A study of 3 citizens' juries on onshore wind farms in Scotland. https://www.climatexchange.org.uk/media/1438/citizens_juries_-_full_report.pdf (Accessed on 25/04/2020)

Roddis, P., Carver, S., Dallimer, M., Norman, P. and Ziv, G. (2018). The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis. *Applied Energy*, 226: 353–364. https://doi.org/10.1016/j.apenergy.2018.05.087

Rydin, Y., Natarajan, L., Lee, M. and Lock, S. (2018). Local voices on renewable energy projects: the performative role of the regulatory process for major offshore infrastructure in England and Wales. *Local Environment*, 23(5): 565–581. https://doi.org/10.1080/13549839.2018.1449821

Scannell, L. and Gifford, R., 2010. Defining place attachment: A tripartite organizing framework. *Journal of Environmental Psychology*, *30*(1):1-10. https://doi.org/10.1016/j.jenvp.2009.09.006

Selman, P. (2010). Learning to Love the Landscapes of Carbon-Neutrality. *Landscape Research*, *35*(2), 157–171. https://doi.org/10.1080/01426390903560414

Sharma, A. (2011). A comprehensive study of solar power in India and World. *Renewable and Sustainable Energy Reviews*, *15*(4), 1767-1776. https://doi.org/10.1016/j.rser.2010.12.017

Simcock, N. (2016). Procedural justice and the implementation of community wind energy projects: A case study from South Yorkshire, UK. *Land Use Policy*, *59*, 467-477. https://doi.org/10.1016/j.landusepol.2016.08.034

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks, London and New Delhi: Sage.

Sütterlin, B. and Siegrist, M. (2017). Public acceptance of renewable energy technologies from an abstract versus concrete perspective and the positive imagery of solar power. *Energy Policy*, 106: 356–366. https://doi.org/10.1016/j.enpol.2017.03.061

Tabi, A. and Wüstenhagen, R. (2017). Keep it local and fish-friendly: Social acceptance of hydropower projects in Switzerland. *Renewable and Sustainable Energy Reviews*, 68: 763– 773. https://doi.org/10.1016/j.rser.2016.10.006

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5): 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

Walker, G. (1995). Renewable energy and the public. *Land Use Policy*, *12*(1): 49-59. https://doi.org/10.1016/0264-8377(95)90074-C

Walker, G. (2009). Beyond distribution and proximity: exploring the multiple spatialities of environmental justice. *Antipode*, 41(4): 614-636. https://doi.org/10.1002/9781444322767.ch1

Warren, C. R., Lumsden, C., O'Dowd, S. and Birnie, R. V. (2005) '"Green On Green": Public perceptions of wind power in Scotland and Ireland', *Journal of Environmental Planning and Management*, 48: 853–875. https://doi.org/10.1080/09640560500294376

White, M. D. and Marsh, E. E. (2006). Content analysis: A flexible methodology. *Library trends*, 55(1): 22-45. https://www.ideals.illinois.edu/handle/2142/3670 (Accessed on 01/06/2020)

Wilson, G. A. and Dyke, S. L. (2016). Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land Use Policy*, 52: 287–296. https://doi.org/10.1016/j.landusepol.2015.12.008

Wolfe, P. (2019). An overview of the world's largest solar power plants. *PV Magazine International*. https://www.pv-magazine.com/2019/06/18/an-overview-of-theworlds-largest-solar-power-plants/ (Accessed on 01/08/2019)

Wolsink, M. (2018). Social acceptance revisited: gaps, questionable trends, and an auspicious perspective. *Energy Research & Social Science*, 46: 287-295. http://doi.org/10.1016/j.erss.2018.07.034

Wüstenhagen, R., Wolsink, M. and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5): 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Yang, H. J., Lim, S. Y. and Yoo, S. H. (2017). The environmental costs of photovoltaic power plants in South Korea: A choice experiment study. *Sustainability*, 9(10): 1–13. https://doi.org/10.3390/su9101773

Yenneti, K. and Day, R. (2015). Procedural (in)justice in the implementation of solar energy: The case of Charanaka solar park, Gujarat, India. *Energy Policy*, 86: 664–673. https://doi.org/10.1016/j.enpol.2015.08.019

Yenneti, K., Day, R. and Golubchikov, O. (2016). Spatial justice and the land politics of renewables: Dispossessing vulnerable communities through solar energy mega-projects. *Geoforum*, 76: 90–99. https://doi.org/10.1016/j.geoforum.2016.09.004

6. Discussion

As outlined in Section 1.3.1, the overarching aim of this thesis is to provide an in-depth understanding of how public acceptance of RE in GB can be described, understood and explained. To achieve this aim, the thesis responds to the following three research questions:

1) What are the key determinants shaping public acceptance of RE in GB?
    a. Community acceptance (onshore wind, solar farms)
    b. Socio-political acceptance (onshore wind, offshore wind, solar, bioenergy, wave/tidal energy)
2) To what extent does public acceptance of RE (community and socio-political) influence RE decision-making in GB?
3) What are the implications of the above findings for GB's low carbon energy transition?

To answer these research questions, the thesis is guided by four research objectives:

- To identify key determinants of public acceptance of RE in GB (both community acceptance and socio-political acceptance)
- To develop an interdisciplinary theoretical framework to articulate key determinants of public acceptance of RE
- To understand the extent to which different dimensions of public acceptance influence RE decision-making in different contexts in GB
- To critically analyse the findings of the thesis and infer implications for GB's low carbon energy transition

This section integrates the findings from the empirical chapters of the thesis (Chapters 3, 4 and 5) to directly address these research questions and objectives (which are initially set out in Chapter 1 and supported by the literature review in Chapter 2). Section 6.1 addresses the first research question and first two objectives, firstly focusing on onshore wind, secondly on solar farms, then other types of RE; Section 6.2 then responds to the second research question and the third objective; and lastly Section 6.3 investigates the third research question and fourth objective.

6.1. Determinants of public acceptance of RE

The first two objectives of this thesis are to identify key determinants of public acceptance of RE in GB and to develop an interdisciplinary theoretical framework to articulate these determinants. These objectives relate to the first research question, as outlined above. Figure 19 presents a theoretical framework synthesising the key findings from across the three empirical chapters of the thesis. This framework is the development of Figure 7, which was created by identifying determinants from existing literature. This framework was tested on planning outcomes for onshore wind and solar farms (Chapter 3), public attitudes towards a range of energy sources (Chapter 4), and online comments and semi-structured interviews on the planning proposal for Cleve Hill Solar Park (Chapter 5). It was then further developed and refined taking account of the insights from the analyses across these chapters. The synthesised framework divides determinants into three categories: those relating to RE *infrastructure*, those relating to the *impacts* of RE, and those relating to the *individual*. It is therefore termed the three 'I' model for public acceptance of RE.

The original framework (Figure 7) distinguished determinants into the following eight categories: aesthetic, environmental, economic, project details (classed as material arguments), demographic, political, temporal, and geographical (classed as social/attitudinal influences). Chapter 3 found that determinants from all categories were statistically significant apart from the political category. Chapter 4 found determinants from all categories to be significant apart from the aesthetic category (project details were not included as the focus was energy technologies in general rather than specific projects). However, 'environmental' in this case refers to environmental attitudes (concern for climate change) rather than environmental impacts of RE infrastructure, leading to 'environmental attitudes' being added to the updated framework. In Chapter 5, determinants were identified for all categories other than demographic, political and geographical (which were not included as this information was not available for this dataset) plus three further categories: 'social', 'construction' and 'process', which have been added to the updated framework.

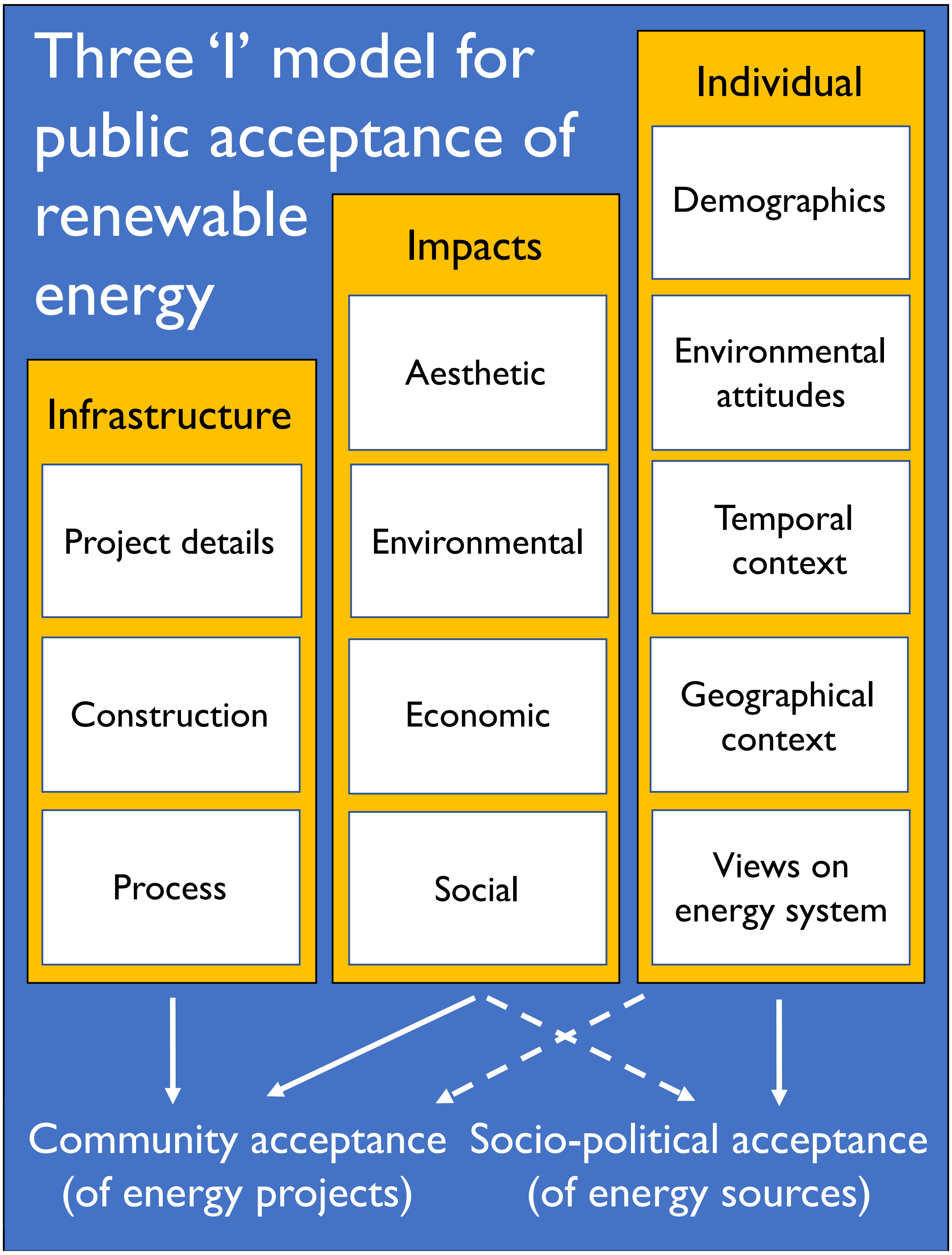

Figure 19. Three 'I' model for public acceptance of renewable energy. Yellow boxes indicate overall categories of determinants: infrastructure, impacts and individual. White boxes indicate types of determinant within these overarching 'I' categories. Solid arrows indicate where this thesis finds strong evidence for a relationship; dashed lines indicate where it finds some evidence but further research is required.

The three 'I' model maintains seven of the eight original categories, plus four additional types of determinants, leading to 12 broad types of determinant within the three overarching 'I' categories. The 'political' determinant is removed as this thesis does not find persuasive evidence for this shaping public acceptance of RE. It is replaced by 'views on energy system' which incorporates the insight from Chapter 5 that public acceptance of RE is relational i.e. embedded within people's views and perceptions of the energy system as a whole. Temporal determinants identified in Chapter 5 (heritage and legacy) are reframed in the three 'I' model as social determinants under the impacts category as this is a better fit with the updated typology. The updated framework removes the classification of material arguments and social/ attitudinal influences in favour of the three 'I' classification as this provides greater nuance and description of what each category refers to. The arrows indicate which dimension of acceptance (community or socio-political) is influenced by each determinant type, with dashed arrows indicating where the thesis finds some evidence but where further research is required. Definitions and examples of each determinant type and the thesis' relevant key findings are provided in Table 9.

The creation of the three 'I' model responds to calls from scholars such as Patrick Devine-Wright for an integrated framework which moves beyond NIMBYism and takes account of the multiple variables which influence how energy technologies are perceived and accepted (2005). Devine-Wright proposes a three-fold framework: personal factors (e.g. age, gender); social-psychological factors (e.g. environmental beliefs, place attachment); and contextual factors (e.g. spatial context) (2007). Dan van der Horst (2007) proposes a three-layered model of acceptance which distinguishes between: opposition to the technology in general (e.g. anti-wind); opposition to the planning process (anti-process); and opposition to other project aspects (anti-project). More recently, Hilary Boudet (2019) proposed a four-fold framework incorporating technology, people, place, and process. Each of these models have contributed to improved understandings of public acceptance of RE.

This thesis builds on and proposes an alternative to these frameworks, adding greater detail on specific types of determinants and demonstrating its value through empirical testing. It also adds the useful distinction between the *infrastructure* itself and the *impacts* of that infrastructure, as well as the role of *individual* factors. Additionally, it connects to Wüstenhagen *et al.*'s (2007) 'triangle of social acceptance' (Figure 5), thereby maintaining this well-known and well-accepted conceptual framing rather than re-inventing the wheel. As discussed by Upham *et al*. (2015), there is a tension between simplicity for non-specialists and academic complexity when designing theoretical frameworks on public acceptance. Following their view that 'it is preferable to set out even a simple framework rather than leave those new to the literature to make their own sense of it over time' (2015, p. 101), the three 'I' model seeks to maximise accessibility (e.g. to policymakers), as well as being grounded in robust academic research, in order to promote rigour and uptake.

Another key advantage of the three 'I' model is that it incorporates multiple disciplinary perspectives including energy geography, energy justice, environmental psychology and ES, as well as being informed by the wider public acceptance literature. This enables it to capture a wide range of determinants which stem from different conceptual backgrounds and academic traditions, so are therefore rarely combined within a single framework. In empirical studies, this means it is difficult to identify the relative importance of these determinants or how they might interact with one another. By taking an interdisciplinary approach, the three 'I' model thus responds to calls for a broader, more integrated approach to energy governance which recognises the range of cross-cutting issues which intersect with energy (Florini and Sovacool, 2011). Following Upham *et al*. (2015), broad relevance and pragmatism is prioritised over strict subscription to any particular theoretical perspective, acknowledging the value in deploying multiple perspectives and integrating knowledge. The three 'I' framework could usefully be employed in future research to test its wider applicability and potentially further developed and refined.

Table 9. Definitions/examples of determinant types identified in the three 'I' model of public acceptance of renewable energy, and key evidence from the thesis to support the inclusion of these determinant types in the three 'I' model.

Category	**Determinant**	**Definitions/examples**	**Key evidence in thesis**
Infrastructure	Project details	Scale, design (e.g. orientation, turbine size), business model (e.g. ownership), end-of-life	Chapter 3: installed capacity, turbine size. Chapter 5: comments on project details.
	Construction	Traffic, noise pollution, air pollution, light pollution	Chapter 5: comments on construction.
	Process	Trust and transparency, mitigation measures, alternative options	Chapter 5: comments on process. Interview data on NSIP process.
Impacts	Aesthetic	Scenic areas e.g. AONBs, wildness, landscape character, land cover, glint/glare	Chapter 3: National Parks, visibility of infrastructure. Chapter 5: comments on aesthetic impacts.
	Environmental	Biodiversity/habitats, flooding, carbon (emissions and sequestration)	Chapter 5: comments on environmental impacts.
	Economic	Agriculture, tourism, employment, property values	Chapter 3: agricultural grade. Chapter 4: jobs. Chapter 5: comments on economic impacts.
	Social	Recreation, heritage, legacy, health and well-being, place attachment	Chapter 5: comments on social impacts.
Individual	Demographics	Age, gender, social class, social deprivation	Chapter 3: deprivation. Chapter 4: age, gender.
	Environmental attitudes	Concern for climate change, belief in nature protection	Chapters 4/ 5: concern for climate change.
	Temporal context	Familiarity effect/exposure, Shifting Baseline Syndrome	Chapter 3: year. Chapter 4: year, SBS.
	Geographical context	Country, region, population density, urban/rural dwelling	Chapter 4: urban/rural. Chapter 5: interview data on local context.
	Views on energy system	Views on wider energy system e.g. energy strategy, alternative policy options.	Chapter 5: interview data, comments on alternative options.

6.1.1. Determinants of public acceptance of onshore wind

Chapter 3 analysed planning decisions as an indicator of the determinants shaping community acceptance of onshore wind and solar farms. For onshore wind, the size of the turbines was found to have the strongest effect, with larger turbines more likely to be approved (Figure 20). However, larger overall wind farms in terms of installed capacity were *less* likely to be approved. If we take planning outcomes to be an (albeit imperfect) indicator of community acceptance, this suggests that fewer larger turbines are more acceptable than many small turbines. This seems to support conclusions from existing research (e.g. Wolsink, 2000) that visual impact is the single strongest determinant, as fewer turbines will have less of an overall visual impact. Although turbine size was categorised as 'project details', this result therefore overlaps with the 'aesthetic' category. This highlights that the categories presented in the three 'I' model are interlinked and may sometimes be overlapping.

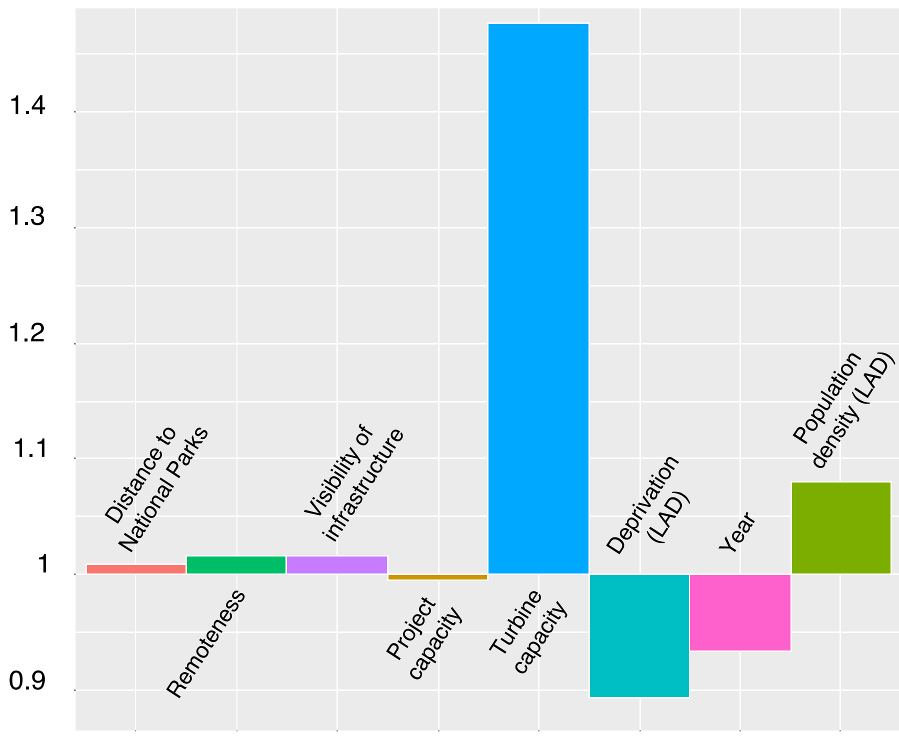

Figure 20. Characteristics of planning applications for onshore wind in Great Britain (1990 – 2017) making them more/less likely to achieve planning success with a 95% confidence level. Bars represent odds ratios (ORs), indicating how the odds of planning success increase or decrease based on a one unit increase in the variable score. ORs above 1 indicate that applications are more likely to be approved as the variable score increases; ORs below 1 indicate that applications are less likely to be approved as the variable score increases.

Other aesthetic variables were also found to have a significant positive effect: distance to National Parks, remoteness, and visibility of existing infrastructure. As highlighted by Harper *et al*. (2019), who conducted a similar study and found a similar result regarding National Parks, this result is weaker than might be expected given that landscape concerns have been so prominent in the discussion around public acceptance of onshore wind. Harper *et al*. (2019) also found distance to Areas of Outstanding Natural Beauty (AONB) to be a significant predictor, in contrast to the findings of this thesis which found it to be slightly short of statistical significance at the 95% confidence level ($p < 0.1$). This may suggest that whilst visual impacts and landscape concerns are important, they are not strictly tied to designated 'scenic' areas and are more related to places which communities are attached to and perceive as aesthetically valuable. Furthermore, as Toke (2005) highlights, there is often overlap between landscape factors and other concerns such as perceived impacts on tourism, particularly in areas which rely on this industry. Thus, whilst aesthetic issues are clearly important, they should not be considered in isolation, again highlighting the interaction between the categories of the three 'I' model.

Notably, the only demographic variable in Chapter 3's analysis found to be significant was social deprivation, as measured by the Townsend Index. This showed that areas of lower deprivation were more likely to approve onshore wind than areas of higher deprivation. This contrasts with findings from other studies, such as van der Horst and Toke (2010) who conducted a similar analysis for onshore wind in rural areas of England between 1991 and 2006. They found that indicators such as higher life expectancy, higher likelihood of voting in national elections, and lower exposure to crime (all associated with wealthier, less deprived communities) were associated with lower planning approval for onshore wind. One explanation for this is the scale at which the analyses were conducted: while this thesis uses LAD given that this is the decision-making level of planning decisions, van der Horst and Toke (2010) use Lower Super Output Area (LSOA) to account for more locally specific variables. This could mean that at a very local level, wealthier communities are relatively more able to oppose unwanted land uses; however in absolute terms, onshore wind is most likely to be located in wealthy LADs (Figure 21), perhaps due to the higher affluence in rural areas of GB where onshore wind is technically most suitable. This may help to explain the political backlash against onshore wind in GB (Devine-Wright and Cowell, 2018), as wealthy communities are more able to organise against unwanted land uses and tend to have greater political influence (van der Horst and Toke, 2010).

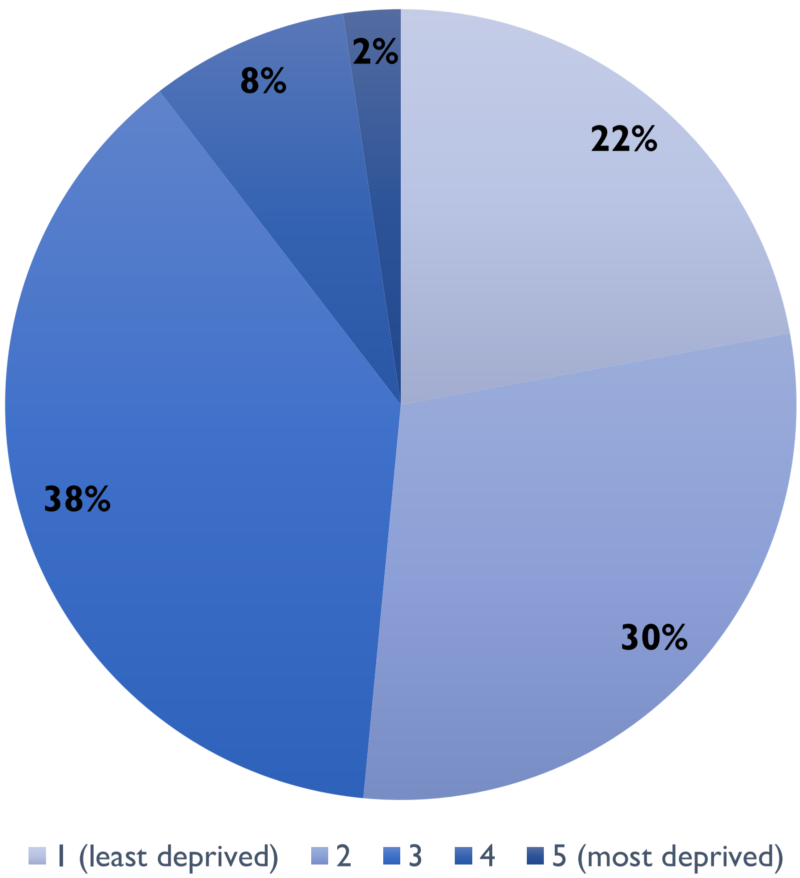

Figure 21. Pie chart showing the distribution of approved onshore wind applications (1990 – 2017) across quintiles of social deprivation in Great Britain (n = 728), as measured by the Townsend Index. Lighter shades indicate lower deprivation.

Chapter 4 investigated socio-political acceptance of onshore wind as part of the analysis of the PAT dataset. In contrast to Chapter 3 which generally did not find demographic characteristics of LADs to be important predictors, this analysis found that some of the strongest predictors of support for onshore wind were demographics. The finding that younger people and women were more likely to be supportive of onshore wind are consistent with existing literature and the thesis' research hypotheses. Finally, Chapter 4 also found employment in the RE sector to be a significant predictor for onshore wind, with people living in regions with higher

RE employment more likely to be supportive. This is an important contribution to the public acceptance literature as there is little empirical evidence in this area.

6.1.2. Determinants of public acceptance of solar farms

For solar farms, the analysis in Chapter 3 found that the strongest effect on planning outcomes was the grade of agricultural land (Figure 22). For example, planning applications on non-agricultural land were on average 4.5 times more likely to be approved than those on the best quality agricultural land. This suggests that communities are less accepting of solar farm developments which conflict with food production or which alter traditional rural landscapes. Chapter 5 further explores community acceptance of solar farms via the case study of Cleve Hill Solar Park. Similarly, it finds that one of the most frequent objections to the project was the landscape character of the proposed site. Much like onshore wind, concerns about landscapes thus appear to be pivotal in community public acceptance of solar farms.

Interestingly however, Chapter 5 found that the most frequent online comment made by the public on the Cleve Hill planning proposal was about biodiversity and habitats. This contrasts with the findings of Chapter 3, which did not find variables relating to biodiversity to be strong predictors. In fact, the proximity to SACs actually had a small but positive affect on the likelihood of approval, through this may be more to do with the type of rural, countryside location where solar farms are best suited (and which are mostly likely to host SACs). These findings indicate that although there is lack of scientific certainty on the impacts of solar farms on biodiversity and these concerns do not appear to be reflected in planning outcomes, there is a strong public perception of risk to wildlife. This is likely to be further exaggerated as further large-scale projects come forward, and projects with novel east-west designs. This highlights that perceptions may differ from actual impacts, raising difficult questions about the extent to which public acceptance should sway decision-making. However, it is clear that the *potential* for harm to wildlife is an important issue for the public which may need to be addressed in public relations.

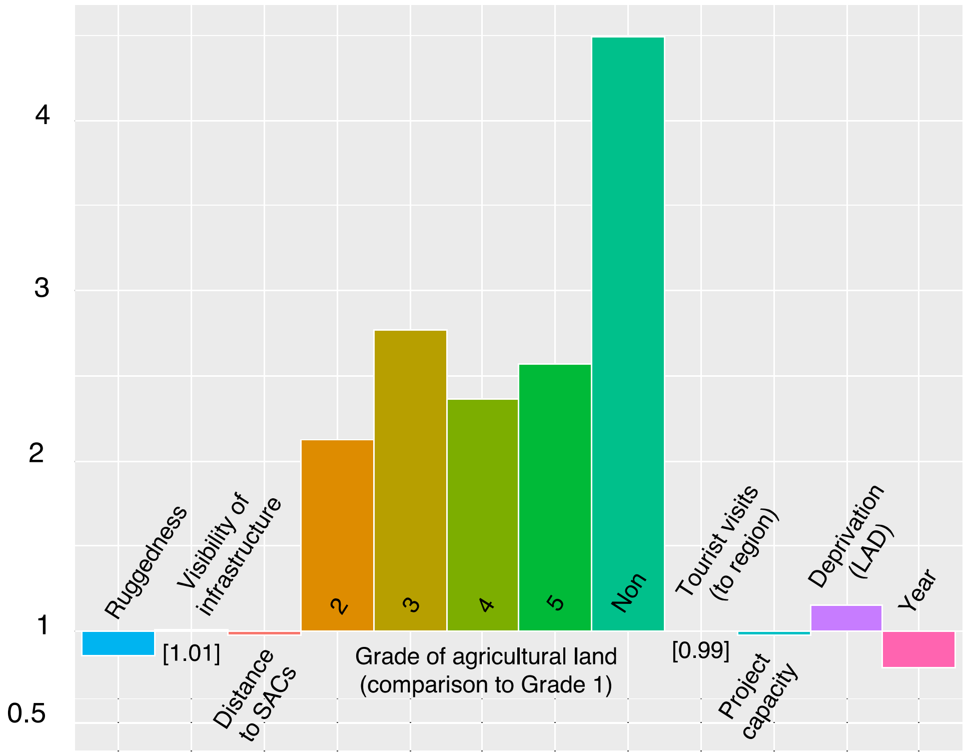

Figure 22. Characteristics of planning applications for solar farms in Great Britain (1990 – 2017) making them more/less likely to achieve planning success with a 95% confidence level. Bars represent odds ratios (ORs), indicating how the odds of planning success increase or decrease based on a one unit increase in the variable score. ORs above 1 indicate that applications are more likely to be approved as the variable score increases; ORs below 1 indicate that applications are less likely to be approved as the variable score increases. Categorical variables are compared to a reference or 'baseline' category.

After concerns around biodiversity and habitats, the scale of the proposed Cleve Hill project was the second most frequent theme identified in the content analysis of online comments. This shows that the physical scale of solar farms is a key influence on community acceptance. Indeed, Chapter 3 found that smaller solar farms (measured by installed capacity) were more likely to be approved, the same as onshore wind. As discussed in Chapter 5, the online comments and associated interviews with local residents were very pejorative about the scale of Cleve Hill, for example describing it as "*ridiculously enormous*" and "*very intrusive height and expanse*". This might be because large-scale projects are typically associated with centralised, government-led energy systems whereas small-scale projects are indicative of a more decentralised, distributed approach involving a broader range of actors such as community groups or local landowners such as farmers.

Indeed, the business model of Cleve Hill (a private company led project) was also identified as a notable theme in the content analysis. As Bridge *et al*. (2013) write, 'the social meaning of renewable energy technologies varies considerably depending on the geographical scale of their deployment as well as the manner or mode in which they are deployed' (p. 338). The fact that scale is an important predictor may therefore also be linked to the *mode* of deployment (e.g. private or community/co-operatively owned), as well as relating to the infrastructure itself and its associated impacts. Again, this emphasises that categories in the three 'I' model are not always distinct and there is often crossover between different aspects.

Interestingly, in a direct contrast to the findings around onshore wind, Chapter 3 found solar farms to be more likely to be approved in areas of *higher* deprivation (Figure 22). This finding is somewhat difficult to interpret but may suggest that solar farms are more of an unwanted land use than onshore wind, which would be a novel contribution to the existing literature. This rests on the assumption that wealthy communities are more able to successfully oppose unwanted developments due to higher social capital (Rydin and Pennington, 2000), and/or that less wealthy communities are more accepting of energy infrastructure (van der Horst, 2007). Importantly, as with onshore wind, when considered in absolute rather than relative terms, solar farms are more likely to be located in less deprived areas (Figure 23).

Therefore, we cannot conclude that solar farms will necessarily become clustered in more deprived communities and thus provoke the attendant issues around energy justice discussed in Chapter 3. However, it may indicate that this could happen in future if the trends identified in Chapter 3 around social deprivation continue, though this would also mean that onshore wind would continue to be deployed in more wealthy communities which would help to balance distribution of impacts. The combination of a justice lens and an ES lens is useful here as it helps to articulate the impacts of RE infrastructure felt by communities (e.g. cultural ES provided by landscapes, provisioning ES provided by land for agricultural production), helping to avoid simplistic accusations of NIMBYism or self-centred protection of local places. This demonstrates how ES can provide a valuable lens for public acceptance of RE.

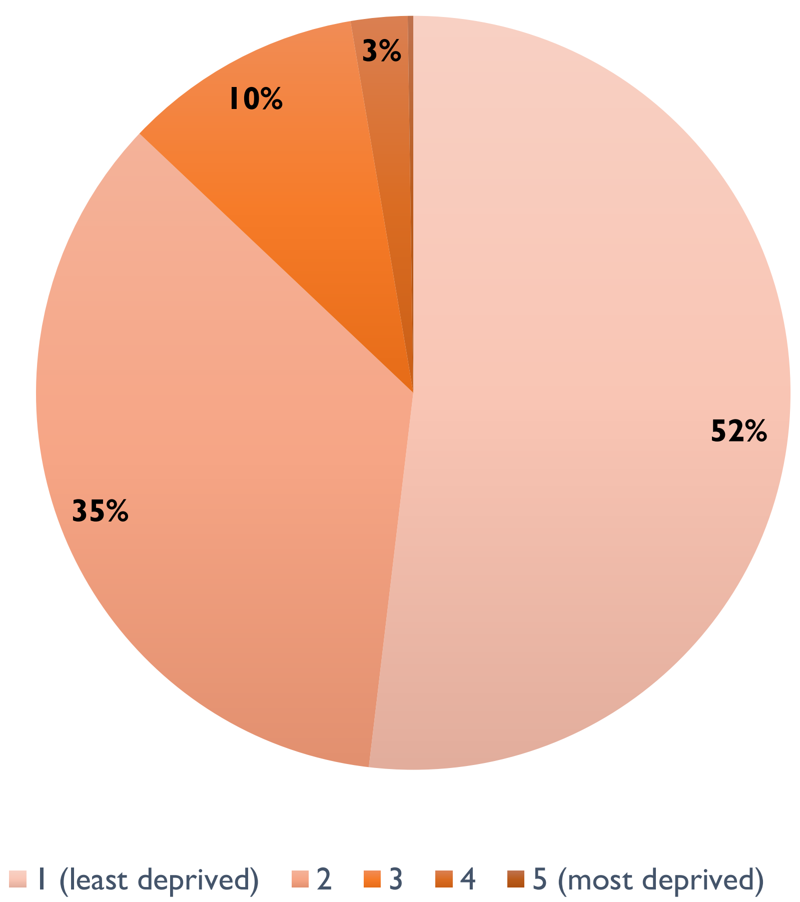

Figure 23. Pie chart showing the distribution of approved solar farm applications (1990 – 2017) across quintiles of social deprivation in Great Britain (n= 1276), as measured by the Townsend Index. Lighter shades indicate lower deprivation.

6.1.3. Determinants of public acceptance of other types of RE

As well as the findings on community acceptance of onshore wind and solar farms, this thesis also contributes insights into socio-political acceptance of other types of RE. Specifically, Chapter 4 analyses public attitudes measured by the PAT towards RE (in general), onshore wind, offshore wind, biomass, wave/tidal and solar (plus nuclear and fracking, though it is acknowledged that the analysis of these is not comprehensive). Consistently, it finds that the strongest predictor of support for all of these energy sources is concern for climate change. Higher concern is associated with greater likelihood of support for RE sources, and lower likelihood of support for nuclear and fracking (which were included in the analysis as the PAT contained comparable data). As concern for climate change increases (see Figure 29 in Appendix 2), and social movements such as Extinction Rebellion and 'School Strikes

4 Climate' raise awareness and public concern for climate change, it seems likely that the trends in support for RE, nuclear and fracking will continue to diverge.

Another important finding of this thesis in relation to other types of RE is the role of demographics in predicting support for different energy sources. After concern for climate change, this was the strongest and most consistent predictor identified in the analysis of the PAT. Nuclear and fracking were both more likely to be supported by older people, men and people in higher social grades (Figure 12). The exception to this trend was that 16-24 year olds were more likely to strongly support fracking than the reference category of 65+ years. This may be explained by lower risk aversion in this age group, or the potential opportunity of employment in the fracking sector. In general however, younger people were more likely than 65+ years to support RE, with this result most pronounced for offshore wind (see Figure 12). The findings around gender suggest that women were (slightly) more likely to support all types of RE other than solar, for which no statistically significant trend was identified. This adds important evidence to the public acceptance literature which has inconsistent findings around the effects of gender (Bertsch *et al.*, 2017).

Interestingly, unlike the results of Chapters 3 and 5, the analysis of the PAT did not show aesthetic determinants to be a significant predictor with the exception of wave/tidal energy (though this correlation may be spurious given the very low deployment of wave and tidal energy in GB). The aesthetic variable included in the regression analysis was percentage visibility of energy infrastructure in the survey respondent's region, estimated using GIS viewshed modelling. However, this was perhaps too coarse a geographical scale to identify meaningful aesthetic effects. Whilst this thesis can therefore offer some insights into public acceptance determinants of RE types other than onshore wind and solar farms, this topic would benefit from further investigation, particularly to gain insights into determinants of community acceptance as this thesis only considers acceptance of other types of RE at the socio-political level.

6.2. Decision-making and public acceptance of RE

The third key objective of this thesis is to understand the extent to which different dimensions of public acceptance influence RE decision-making, relating to the second research question: *To what extent does public acceptance of RE (community and socio-political) influence RE decision-making in GB?* To address this question, the thesis has considered the influence of public acceptance on decision-making in different contexts in GB: local planning decisions (Chapter 3), national policymaking (Chapter 4), and national planning processes under the NSIP regime (Chapter 5). Table 10 summarises the key findings of the thesis in relation to these contexts.

Table 10. Matrix showing the influence of public acceptance on RE decision-making in different contexts in Great Britain

	Local planning	**National policymaking**	**National planning**
Community acceptance	Acceptance variables have some predictive power for planning decisions for onshore wind and solar farms (Nagelkerke R2 = 26% and 13% respectively)	Lack of community acceptance may lead to national policy changes e.g. cuts / removal of subsidies for onshore wind and solar farms	Community acceptance may play a role but NSIPs are underpinned by a presumption of national need, making local opposition less likely to be effective
Socio-political acceptance	Solar is the most popular energy source in the PAT and has higher planning acceptance rates (81%) compared to onshore wind (57%); this may suggest that socio-political acceptance minimises local opposition to RE planning proposals	Public support for RE is not strongly reflected in UK government policy; fracking and nuclear are supported by UK government despite low public support; Scottish and Welsh governments appear more responsive to public opinion	National planning is underpinned by policy statements identifying sectoral strategies; the public were consulted but statements are now institutionalised so are assumed to have socio-political acceptance; the public can only engage on a case-by-case project basis

6.2.1. Community acceptance

The type of relationship most commonly discussed in public acceptance of RE literature and within policy discourse is the top-left of Table 10: the relationship between *community acceptance* and *local planning* (e.g. Aitken *et al.* 2008). This refers to the role of local communities in planning decisions, which is explored in this thesis in Chapter 3. The results of this chapter show that variables related to community acceptance of onshore wind and solar farms had some predictive power over planning outcomes for these types of RE in GB between 1990 and 2017, approximately 26% and 13% respectively. It can't be ruled out that these were not driven by other planning considerations (such as the national policy to protect the 'best and most versatile' land) or by other pressure groups or organisations who engage with planning processes such as landscape and wildlife protection groups. However, the indication from these results and other studies (e.g. Liljenfeldt and Pettersson, 2017; van der Horst and Toke, 2010) is that communities can have an effect on planning outcomes amongst other factors (e.g. Harper *et al*., 2019), although other studies do find this effect to be limited (e.g. Aitken *et al*. 2008).

Lack of community acceptance of RE infrastructure matters because it extends the time taken for RE projects to progress through the planning system, or in some cases prevents them all together (Eltham *et al*., 2008; Wilson and Dyke, 2016). Additionally, evidence suggests that frequent planning refusals (which can be a result of public opposition) increases development costs, which may deter the investment needed to deliver RE at the necessary pace and scale (RenewableUK, 2015). Furthermore, in some cases it may have a broader influence on national policymaking (top-centre, Table 10). For example, onshore wind caused much public controversy in GB at the local level, leading to statements in the UK Conservative Party's 2015 election manifesto to 'halt the spread of onshore wind farms' (Murray and Shankleman, 2015). Following the Conservative's electoral success, changes were made to the planning process whereby full control over decision-making for onshore wind was devolved to local planning authorities, including for large-scale (50 MW+) projects which were previously classified as NSIPs and therefore decided centrally (Cowell and Devine-Wright, 2018). Additionally, all onshore wind proposals must be located in designated sites in a local or neighbourhood plan and be able to demonstrate the backing of the community (Cowell and Devine-Wright, 2018). This shows that community acceptance can sometimes influence national policymaking.

However, it is important to note that this influence does not occur in all cases where infrastructure is controversial at a local level (Rootes, 2013). For example, Grubb and Newbery (2018) argue that the UK Conservative Government's changes to onshore wind policy were a 'political ban' designed to appeal to affluent, rural constituencies who are likely to vote Conservative. Indeed, if we consider this in the context of the demographic findings from Chapter 4, we can see that the demographic most likely to vote Conservative (older people) are substantially less likely to support onshore wind, suggesting that the Conservatives designed this policy to appeal to their base. Chapter 4 also shows that onshore wind is less likely to be supported in rural areas, supporting this hypothesis. This suggests that community acceptance is more likely to influence policymaking when there is a wider political benefit to decision-makers. It is possible that cuts in subsidies for solar farms (Burke, 2015) was motivated by a similar rationale (Figure 13), possibly to pre-empt the same kind of backlash against solar farms as experienced by onshore wind in Conservative-voting rural areas[4].

The relationship depicted in the top-right of Table 10 is between community acceptance and national planning processes such as the NSIP regime. NSIPs were established under the Planning Act 2008 with the intention of streamlining planning for major infrastructure, thereby making it 'fairer and faster' (Planning Inspectorate, 2016). The NSIP regime is underpinned by National Policy Statements (NPSs), which set out the UK Government's objectives for the development of nationally significant infrastructure in a particular sector. Therefore, although NSIPs must adhere to the robust planning regulations and environmental assessments which apply to any infrastructure development, there is an underlying presumption of national need. The case study of Cleve Hill in Chapter 5 demonstrates that the public can engage with NSIP planning processes in a number of ways: through making online representations, through attending and contributing to public hearings, and by organising campaigns to mobilise a broader public. However, despite these

[4] In March 2020, subsidies for onshore wind were reinstated by the UK Conservative Government under the Contracts for Difference (CfD) scheme (Pickard, 2020). Solar farms can also apply for CfDs, the cuts in subsidies referred to here are the Renewables Obligation (RO) and Feed-In Tariffs (FiTs).

activities, the Planning Inspectorate recommended the application was approved in February 2020 and was ultimately approved by the Secretary of State in May 2020.

The official letter outlining the Secretary of State's decision does acknowledge that local residents had a number of concerns including landscape and visual effects, biodiversity conservation and cultural heritage which were given weight in the 'planning balance' i.e. the decision-making process. However, it states that 'the Secretary of State has considered all the merits and disbenefits of the proposed Development and concluded that, on balance, the benefits of the Development outweigh its negative impacts' (BEIS, 2020, p. 37). This is despite the conclusion that 'there would be no significant positive economic effect in the region' (BEIS, 2020, p. 20). The main reason given for granting the application was that the Overarching NPS for Energy (EN-1) gives support to renewable electricity generating stations, which although does not explicitly refer to solar farms or battery storage facilities was deemed to extend to these technologies. Land use effects were not deemed to be significant as the land around and under the solar panels would be planted with wildflowers and grazed by sheep, which was considered would improve biodiversity.

Some changes to the application were made during the planning process which seem to respond to concerns raised by the community. These include changing the proposed standalone battery storage system to a containerised proposal to reduce fire risk and reducing the number of access routes to the site from two to one. This relatively minor effect on decision-making aligns with other research on energy NSIPs highlighting the highly circumscribed role that local publics play in NSIP planning processes (Natarajan *et al*., 2018) and the low likelihood of influencing a decision because of the strength of political and policy backing (Johnstone, 2014). Thus, it appears communities have limited influence on national planning decisions.

6.2.2. Socio-political acceptance

In terms of socio-political acceptance, there is less of a direct mechanism between the public and RE decision-making processes. Rather, as highlighted by Wolsink

(2018), socio-political acceptance sets the broader conditions for energy decision-making. The bottom left of Table 10 refers to the relationship between socio-political acceptance and local planning decisions. The findings of this thesis suggest there is perhaps some relationship between more socio-politically acceptable energy sources and increased likelihood of planning success. For instance, Chapter 4 shows that solar is the most socio-politically accepted energy source (mean 82.% between 2012 and 2018) and Chapter 3 shows solar to have relatively high planning acceptance rates (81% between 1990 and 2017). Correspondingly, onshore wind has lower socio-political acceptance (mean 68.1% between 2012 and 2018) and lower planning acceptance rates (57% between 1990 and 2017). This potentially indicates that socio-political acceptance minimises local opposition to RE planning proposals, perhaps due to being a less 'stigmatised' technology. This is supported by the finding in Chapter 5 that people take social cues from their peers to construct their views.

The effect of socio-political acceptance on national policymaking (bottom-centre of Table 10) also appears limited. For instance, as shown in Chapter 4, UK Government policy does not reflect the trends in public attitudes for RE, nuclear and fracking. In fact, over the time period of the chapter's analysis (2012 to 2018), UK policy moved away from RE and towards nuclear and fracking (Barnham, 2017), although UK energy minister Kwasi Kwarteng recently commented that 'fracking is over' in the UK (Cockburn, 2020). Therefore, although measures of socio-political acceptance such as the PAT survey are reportedly frequently drawn on by decision-makers (Batel and Devine-Wright, 2015), the actual role they play in decision-making processes is unclear. Indeed, the rationale given for removing subsidies for onshore wind given by the UK Government in 2015 was that "we are reaching the limits of what […] the public is prepared to accept" (DECC, 2015). However, the PAT shows that support for onshore wind was in fact *increasing* over this time (2012-2018). This suggests that community acceptance (along with other political motivations) are a much stronger influence on national policymaking than socio-political acceptance.

However, the devolved administrations of GB (the Scottish and Welsh governments) indicate a slightly different trend. For example, Chapter 4 found there to be notably lower than average support for nuclear and fracking in Scotland and the development of both of these technologies are effectively banned by the presiding Scottish National Party (SNP) (Carrell, 2019; Scottish Government, 2020). This may suggest that the Scottish Government are more responsive to public opinion than the UK Government. However, Scotland was also found to have lower than average support for RE technologies and the SNP has generally created a supportive policy environment for RE, which runs counter to this hypothesis. The Welsh Government has also imposed a moratorium on fracking, taking account of low public support, though continues to support nuclear despite below average support. However, this may be a reflection of the greater devolution of planning powers to Scotland than to Wales; UK Government policy therefore has greater influence over the Welsh than the Scottish planning system. Further geographically contextual and political-science informed analysis would be beneficial here, exploring the role of politics, devolution and the rise of populism in various contexts on RE decision-making.

Finally, the bottom-right of Table 10 shows the relationship between socio-political acceptance and national planning processes. As previously noted, the NSIP regime is underpinned by NPSs which set out the UK Government's objectives for the development of nationally significant infrastructure in a particular sector. The Overarching NPS for Energy (EN-1) and the NPS for Renewable Energy Infrastructure (EN-3) were adopted in 2011 and followed the UK Government's standard public consultation process, whereby members of the public were able to feed in their views by responding to pre-set questions. The UK Government's response shows that some minor technical changes were made to the NPSs following this consultation process (DECC, 2011a, p. 154). However, once adopted the statements remains in force unless the UK Government decides to withdraw or suspend it (DECC, 2011b). This demonstrates that there is no formal ongoing opportunity for the British public to influence national planning processes for RE infrastructure other than by engaging on a case-by-case basis on specific projects.

This is described by Matthew Cotton as the 'depoliticisation' of infrastructure planning with the aim of speeding up low carbon transition processes (Cotton, 2018).

He argues that 'it creates opportunities for a rescaling of politics that allows central authorities to impose unwanted site selection, diminishing the capacity for communities to oppose unjust environmental decisions through dialogue and facilitated exchange within an appropriate space of engagement' (2018, p. 252). For example, the 'Save Graveney Marshes' campaign opposing Cleve Hill decided to take their campaign to the UK Parliament (Figure 24) by arranging a Parliamentary debate and press conference in an attempt to *re*-politicise the decision-making process. As Cotton highlights, this is an example of what public participation scholar Jason Chilvers terms '*uninvited* forms of engagement [...] pushing citizens into direct action and vocal social movements of opposition as their political power in formal, invited spaces of engagement diminishes' (Cotton, 2018, p. 253). This shows that as well as the avenues identified in this thesis, public acceptance may also engage with and influence decision-making in spontaneous and unexpected ways, supporting the description of public engagement in energy transitions as *diverse*, *co-produced* and *emergent* rather than institutionally pre-defined (Chilvers and Longhurt, 2016). It remains to be seen the extent to which this type of activity will influence RE decision-making, something which could be valuably explored in future research.

Figure 24. 'Save Graveney Marshes' campaigners opposing Cleve Hill Solar Park with local MP Helen Whateley (third from right) outside UK Parliament (Davis, 2019)

6.3. Implications for GB's low carbon energy transition

The fourth and final objective of this thesis is to critically analyse the findings of the research and infer implications for GB's low carbon energy transition. This section does this first by considering implications for energy policy and project design (Section 6.3.1); then by exploring implications for decision-making processes (Section 6.3.2); and finally by delineating implications for theories of public acceptance and possible applications of the three 'I' framework (Section 6.3.3).

6.3.1. Implications for energy policy and project design

The findings of this thesis have implications for how RE projects can be designed in a way that is sensitive to public preferences. Chapter 3 of the thesis provides insights into the types of onshore wind and solar farms that are most likely to be accepted by communities. It finds that a key issue is project scale, with smaller projects more likely to be accepted than larger ones. This is supported by the findings of Chapter 5 which found project scale to be a major concern regarding Cleve Hill Solar Park. This is interconnected with other issues such as place attachment, loss of land for recreation, and green-on-green impacts which are exacerbated by larger projects.

Interestingly, Chapter 3 found that whilst smaller overall projects were more likely to be accepted, smaller individual wind turbines were *less* likely to be accepted. In other words, larger wind turbines (i.e. the capacity of the individual turbines) were more likely to be accepted than smaller ones. This suggests that fewer larger turbines are perhaps more acceptable to communities than wind farms with many small turbines. A possible explanation for this is the visual impact of individual turbines is lower than multiple turbines, thereby reducing the loss of visual amenity.

Another explanation for these findings could be that large-scale projects are typically associated with centralised, government-led energy systems whereas small-scale projects are indicative of a more decentralised, distributed approach involving a broader range of actors. As discussed in Section 6.1.2., the 'social meaning' of RE technologies can be shaped by 'the manner or mode in which they are deployed' (Bridge *et al.*, 2013, p. 338). Thus, a possible implication is that smaller scale projects are more likely to be accepted because of the ownership of projects, suggesting that community ownership should perhaps be prioritised by policy.

For solar farms, Chapter 3 found that the grade of agricultural land was another significant variable affecting planning outcomes. Whilst this was not identified as a prominent concern in Chapter 5 regarding Cleve Hill, impacts on landscape character was a common concern raised in the online comments. This indicates that for solar farms, impacts on land use are an important consideration when designing projects that are sensitive to public preferences. Regulations on the amount of land that can be used for a single energy project could potentially be beneficial, and/or the types of land that are available for energy development. For example, brownfield sites and former industrial sites could be prioritised for solar farm development over greenfield sites and high-grade agricultural land (or these types of land could be excluded from solar farm development). Alternatively, rooftop solar PV could be prioritised over ground-mounted PV in order to avoid land use conflicts. An ES approach may be helpful here to inform energy planning and to strategically plan how best to use land to manage synergies and trade-offs (Holland *et al.*, 2016).

Impacts (and *potential* impacts) on biodiversity were also identified by Chapter 5 as an important consideration for solar farm design. This could also be addressed by establishing guidance or regulation on types of land available for solar farm development, for instance excluding land adjacent to protected areas for biodiversity. Importantly, NSIPs are currently exempt from the requirement to deliver 'net gain' for biodiversity which may be exacerbating this issue and should potentially be reconsidered (ENDS, 2020). Further research is required into the ecological impacts of solar farms to determine how best to achieve biodiversity net gain in this context, particularly for novel east-west panel designs such as Cleve Hill.

Finally, whilst not necessary a 'silver bullet' (Cass *et al.*, 2010), community benefit funds can be an important aspect of project design for enhancing public acceptance of RE and more evenly distributing costs and benefits. All energy infrastructure inevitably entails some impacts and is therefore likely to attract some level of public opposition. To redress the balance between local impacts and national and/or global benefits, community benefit funds could be mandated for all RE projects above a certain size e.g. NSIPS (which are over 50 MW by definition) or which receive subsidies such as a Contract-for-Difference (CfD): the UK's current main RE subsidy mechanism. This may help to improve perceptions of fairness of RE transitions and thereby facilitate a smooth, rapid and just transition that is acceptable to the public.

6.3.2. Implications for decision-making processes

The thesis also holds implications for how RE decision-making processes operate. Chapter 4 demonstrates there is a divide between public preferences for GB's low carbon transition and the preferences of policymakers steering this transition. This is a problem because it may erode trust in decision-making institutions and damage the social license of energy industries to operate if the public perceive themselves as being ignored. There are also normative rationales for pursuing energy policies in line with public preferences, as discussed in Section 1.3.2. Thus, there is a need to address this gap between public preferences and the direction of UK energy policy.

One way in which this could be achieved is through the introduction of deliberative processes into energy policymaking and planning in order to provide a forum for public debate. At present, there is a lack of opportunity in the UK planning system for 'democratic discussion of how the fundamental societal objectives that underlie proposed developments can be achieved' (van der Horst, 2007, p. 2713). As Roberts and Escobar (2015) demonstrate in relation to onshore wind, deliberation can help to moderate extreme views and increase understanding of the trade-offs involved in decision-making surrounding low carbon transitions. It also has to potential to make planning and policy decisions more reflective of public preferences, though it is acknowledged that there is not necessarily a guarantee in this regard. Positive examples of this are the UK Climate Citizen's Assembly held by six House of Commons' Select Committees in 2020 and the Leeds Climate Change Citizens' Jury held in 2019 by the Leeds Climate Commission, which gathered representative samples of the population to deliberate on climate and energy policies (Scott, 2019).

This type of initiative is additionally valuable as the results of the thesis suggest that some sections of the public are having a stronger effect on energy policy than others. Chapter 4 found that young people and women were more likely to support renewables, while older people, men and higher social classes were more likely to support nuclear and fracking. It is perhaps not a coincidence that this demographic group has the most similar views to the UK's energy policy, given the lack of diversity in the energy sector (Laville, 2019). As well as emphasising the value of deliberative decision-making processes which are inclusive of multiple perspectives, this also highlights the need to have people of all social backgrounds in the top energy jobs so that decisions are more representative of the whole of society and its preferences.

Finally, the thesis indicates a need to address how less powerful stakeholders are engaged in decision-making processes to ensure that RE infrastructure does not becomes a new form of uneven development across social groups, with attendant issues of distributive and procedural justice. Deliberative processes whereby members of the public are randomly selected to participate may help to balance uneven capacity to engage in decision-making processes across social groups, as discussed in Chapter 3 in relation to local planning. However, this would need to be compensated in some way to ensure that people were not disadvantaged by giving their time. Another approach could be to improve consultation processes so that developers and planning bodies are required to more proactively engage with hard-to-reach communities. As found in Chapter 5 of the thesis, consultation processes are not always systematic and there is definite scope to make them more inclusive.

6.3.3. Implications for theories of public acceptance

The findings of this thesis also have implications for how the academic literature theorises public acceptance processes. For example, the concept of the 'social gap' by Bell *et al*. (2005) has been influential in conceptualising public acceptance of RE, referring to the 'gap' between high socio-political acceptance of a technology but low rates of planning acceptance (e.g. onshore wind). The authors posit three potential explanations: 1) there is a *democratic deficit* in planning processes which means that decisions reflect a vocal minority rather than the will of the majority; 2) people have *qualified support* for wind energy, whereby they support developments only if they meet certain conditions; 3) people are self-interested 'NIMBYs' who support wind energy in general but not in their local area. In a later paper (Bell *et al*. 2013), the authors revisit their explanatory framework and add a further explanation for the social gap: the *place protector*, building on Patrick Devine-Wright's work on place attachment. The place protector differs from the NIMBY because their actions are not self-interested (they are motivated by wanting to protect the place itself), and their support is not qualified in a formalised way e.g. the belief that a 'good' project must not negatively impact wildlife or designated scenic areas. Instead, 'the place-protector opposes a local development because of the value that she sees in that particular place while not seeing the same value or remaining agnostic on the value of other places where developments might take place' (Bell *et al*., 2013, p. 123).

The findings of this thesis suggest that the NIMBY explanation is an unhelpful account because it overlooks the wide range of determinants shaping public acceptance of RE (see Section 6.1), as depicted in the three 'I' model (Figure 19). The findings of this thesis therefore add to the body of literature which regard NIMBYism as an unsatisfactory explanation for public acceptance of RE processes. It finds more convincing evidence for the 'place protector' explanation, for example the results of Chapter 5 show that the local community were highly motivated by the desire to protect the Graveney Marshes area. It also finds some evidence of a democratic deficit by showing that public preferences are not necessarily reflected in decision-making (see Section 6.2.2). However, the explanation most supported by the thesis is the idea of 'qualified support' i.e. that people do generally support RE and recognise the importance of climate change mitigation, but they do not necessarily support specific RE projects. For instance, this was a common theme identified in Chapter 5 in which most interviews and online comments were generally supportive of solar farms but not Cleve Hill due to specific issues associated with that project.

Interestingly however, Susana Batel and Patrick Devine-Wright (2015) have more recently questioned whether the framing of a national-local 'gap' is actually helpful for diagnosing the empirical situation. They argue that the framing of a national-local gap is misleading because there is a non-correspondence in how public responses are measured at each of these levels. As they put it (2015, p. 1077):

> *"…the very definition of the national-local gap – as the paradox between public or national support in general, and local opposition for specific projects to be constructed near the place where people live – diagnoses that a gap exists based on the comparison of national and local responses at two different, non-correspondent levels: energy infrastructure in general vs. specific projects to be constructed near the place where respondents live."*

Indeed, the methods employed in this thesis exemplify that different techniques are more and less suited to measuring public acceptance at local and national scales. A key recommendation arising from the thesis is therefore that policymakers should improve the ways in which measure public acceptance of RE is measured in order to achieve more comparable measurements of public acceptance at local and national scales, and thus ascertain whether there is indeed a 'gap' between these dimensions.

Indeed, as pointed out by Batel and Devine-Wright (2015), although surveys such as the PAT were established to help policymakers understand how energy policies are likely to be received by the public, they do not adequately cover the range of factors which shape public acceptance. They consequently argue that the determinants which research shows to be relevant to community acceptance should also be measured when considering socio-political acceptance. The three 'I' model proposed in Section 6.1 of this thesis could be a helpful tool in this regard. What makes this framework fairly unique is that it has been developed, tested and refined with both community *and* socio-political acceptance in mind. This means it captures determinants which are relevant to each of these aspects. The framework could therefore potentially be utilised by policymakers to understand the determinants shaping public acceptance at each of these levels and to measure these determinants more consistently across a broader population. This could be achieved, for example, by broadening the range of questions that are asked in national surveys such as the PAT. This would improve commensurability between understandings of public acceptance at local and national levels and more accurately diagnose whether there is indeed a ‘gap’ between these dimensions of acceptance.

6.4. References

Aitken, M., McDonald, S., and Strachan, P. (2008). Locating "power" in wind power planning processes: the (not so) influential role of local objectors. *Journal of Environmental Planning and Management*, 51(6), 777–799. https://doi.org/10.1080/09640560802423566

Barnham, K. (2017). Challenge Conservatives on energy priorities and cuts to renewables. *The Guardian*. https://www.theguardian.com/environment/2017/may/10/challenge-conservatives-energy-priorities-cuts-renewables (Accessed on 25/04/2020)

Batel, S., and Devine-Wright, P. (2015). A critical and empirical analysis of the national-local 'gap'in public responses to large-scale energy infrastructures. *Journal of Environmental Planning and Management*, 58(6), 1076-1095. https://doi.org/10.1080/09640568.2014.914020

BEIS (UK Department for Business, Energy and Industrial Strategy). (2020). Secretary of State Decision Letter. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010085/EN010085-001956-200528%20EN010085%20CHSP%20Secretary%20of%20State's%20Decision%20Letter.pdf (Accessed on 28/06/2020)

Bell, D., Gray, T. and Haggett, C. (2005). The "social gap" in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, 14(4): 460–477. https://doi.org/10.1080/09644010500175833.

Bell, D., Gray, T., Haggett, C., and Swaffield, J. (2013). Re-visiting the "social gap": public opinion and relations of power in the local politics of wind energy. *Environmental Politics*, 22(1), 115-135. https://doi.org/10.1080/09644016.2013.755793

Bertsch, V., Hyland, M., and Mahony, M. (2017). What drives people's opinions of electricity infrastructure? Empirical evidence from Ireland. *Energy Policy*, 106, 472–497. http://doi.org/10.1016/j.enpol.2017.04.008

Boudet, H. S. (2019). Public perceptions of and responses to new energy technologies. *Nature Energy*, 4(6), 446-455. https://doi.org/10.1038/s41560-

019-0399-x

Bridge, G., Bouzarovski, S., Bradshaw, M., and Eyre, N. (2013). Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*, 53, 331–340. https://doi.org/10.1016/j.enpol.2012.10.066

Burke, M. (2015). Solar Farms: Funding, planning and impacts. House of Commons Library: Briefing Paper. https://researchbriefings.files.parliament.uk/documents/CBP-7434/CBP-7434.pdf (Accessed on 01/02/2020)

Carrell, S. (2019). Scottish government extends ban on fracking. *The Guardian*. https://www.theguardian.com/uk-news/2019/oct/03/scottish-government-extends-ban-on-fracking (Accessed on 25/04/2020)

Cass, N., Walker, G. and Devine-Wright, P. (2010). Good neighbours, public relations and bribes: the politics and perceptions of community benefit provision in renewable energy development in the UK. *Journal of Environmental Policy & Planning*, *12*(3), pp.255-275. https://doi.org/10.1080/1523908X.2010.509558

Chilvers, J., and Longhurst, N. (2016). Participation in transition (s): Reconceiving public engagements in energy transitions as co-produced, emergent and diverse. *Journal of Environmental Policy and Planning*, 18(5), 585-607. https://doi.org/10.1080/1523908X.2015.1110483

Chilvers, J. (2010). *Sustainable participation? Mapping out and reflecting on the field of public dialogue on science and technology*. Harwell: Sciencewise Expert Resource Centre.

Cockburn, H. (2020). Climate crisis: "Fracking is over" in UK, energy minister says. *The Independent*. https://www.independent.co.uk/environment/fracking-ban-uk-kwasi-kwarteng-climate-change-methane-shale-gas-a9575906.html (Accessed on 28/06/2020)

Cotton, M. (2018). Environmental Justice as Scalar Parity: Lessons From Nuclear Waste Management. *Social Justice Research*, *31*(3), 238-259. https://doi.org/10.1007/s11211-018-0311-z

Cowell, R., and Devine-Wright, P. (2018). A "delivery-democracy dilemma"? Mapping and explaining policy change for public engagement with energy infrastructure. *Journal of Environmental Policy and Planning*, 20(4), 499-517. https://doi.org/10.1080/1523908X.2018.1443005

Davis, K. (2019). Campaigners and Faversham MP Helen Whateley take Cleve Hill Solar Park fight to Parliament. *Kent Online*. https://www.kentonline.co.uk/faversham/news/campaigners-take-solar-park-fight-to-parliament-212043/ (Accessed on 25/04/2020)

DECC (Department of Energy and Climate Change). (2011a). The Government Response to Consultation on the Revised Draft National Policy Statements for Energy Infrastructure. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37053/1945-govt-resp-consultation-on-nps.pdf (Accessed on 25/04/2020)

DECC (Department of Energy and Climate Change). (2011b). National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37048/1940-nps-renewable-energy-en3.pdf (Accessed on 25/04/2020)

DECC (Department of Energy and Climate Change). (2015). Statement on ending subsidies for onshore wind. https://www.gov.uk/government/speeches/statement-on-ending-subsidies-for-onshore-wind (Accessed on 25/04/2020)

Devine-Wright, P. (2005). Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*, 8(2), 125–139. https://doi.org/10.1002/we.124

Eltham, D. C., Harrison, G. P., and Allen, S. J. (2008). Change in public attitudes towards a Cornish wind farm: Implications for planning. *Energy Policy*, 36(1), 23–33. https://doi.org/10.1016/j.enpol.2007.09.010

ENDS (2020). Government mulls mandatory net gain for major infrastructure projects. https://www.endsreport.com/article/1675211/government-mulls-mandatory-net-gain-major-infrastructure-projects (Accessed 12/08/2020)

Florini, A., and Sovacool, B. K. (2011). Bridging the gaps in global energy governance. *Global Governance*, 57-74. https://ink.library.smu.edu.sg/soss_research/2091

Grubb, M., and Newbery, D. (2018). UK Electricity Market Reform and the Energy Transition: Emerging Lessons. MIT Centre for Energy and Environmental Policy Research, Working Paper Series. https://doi.org/10.17863/CAM.24680

Harper, M., Anderson, B., James, P. A., and Bahaj, A. S. (2019). Onshore wind and the likelihood of planning acceptance: Learning from a Great Britain context. *Energy Policy*, 128, 954-966. https://doi.org/10.1016/j.enpol.2019.01.002

Holland, R. A., Scott, K., Hinton, E. D., Austen, M. C., Barrett, J., Beaumont, N., Taylor, G. (2016). Bridging the gap between energy and the environment. *Energy Policy*, 92, 181–189. https://doi.org/10.1016/j.enpol.2016.01.037

Johnstone, P. (2014). Planning reform, rescaling, and the construction of the postpolitical: the case of The Planning Act 2008 and nuclear power consultation in the UK. *Environment and Planning C: Politics and Space*, 32(4): 697–713. https://doi.org/10.1068/c1225.

Laville, S. (2019). UK energy companies fail to promote women to executive roles. *The Guardian*. https://www.theguardian.com/business/2019/may/16/uk-energy-companies-fail-to-promote-women-to-executive-roles (Accessed on 12/08/2020)

Liljenfeldt, J., and Pettersson, Ö. (2017). Distributional justice in Swedish wind power development – An odds ratio analysis of windmill localization and local residents' socio-economic characteristics. *Energy Policy*, 105, 648–657. http://doi.org/10.1016/j.enpol.2017.03.007

Murray, J. and Shankleman, J. 2015. Tory manifesto vows to halt the spread of onshore wind farms. *Business Green*. https://www.businessgreen.com/news/2403945/tory-manifesto-vows-to-halt-the-spread-of-onshore-windfarms (Accessed on 25/02/2020)

Natarajan, L., Rydin, Y., Lock, S. J. and Lee, M. (2018). Navigating the participatory processes of renewable energy infrastructure regulation: A "local participant perspective" on the NSIPs regime in England and Wales. *Energy Policy*, 114:201–210. https://doi.org/10.1016/j.enpol.2017.12.006.

Pickard, Jim. (2010). Johnson revives onshore wind-farms after 4 year ban. *Financial Times*. https://www.ft.com/content/b8ddb2f4-5c83-11ea-8033-fa40a0d65a98 (Accessed on 25/02/2020)

Planning Inspectorate. (2016). Advice Note 8: Overview of the nationally significant infrastructure planning process for members of the public and others. https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/04/Advice-note-8.0.pdf (Accessed on 25/04/2020)

RenewableUK. (2015). Onshore Wind Cost Reduction Taskforce Report. https://www.renewableuk.com/news/304386/Onshore-Wind-Cost-Reduction-Taskforce-Report.htm (Accessed on 25/04/2020)

Roberts, J. and Escobar, O. (2015). Involving communities in deliberation: A study of 3 citizens' juries on onshore wind farms in Scotland. https://www.climatexchange.org.uk/media/1438/citizens_juries_-_full_report.pdf (Accessed on 25/04/2020)

Rootes, C. (2013). From local conflict to national issue: when and how environmental campaigns succeed in transcending the local. *Environmental Politics*, 22(1): 95–114. https://doi.org/10.1080/09644016.2013.755791.

Rydin, Y. and Pennington, M. (2000). Public participation and local environmental planning: the collective action problem and the potential of social capital. *Local Environment*, 5(2): 153–169. doi.org/10.1080/13549830050009328

Scott, Geraldine. (2019). 'We must lead revolution on the environment,' says Leeds citizens' jury. *Yorkshire Evening Post.* https://www.yorkshireeveningpost.co.uk/news/we-must-lead-revolution-environment-says-leeds-citizens-jury-1324163 (Accessed on 10/03/2020)

Scottish Government. (2020). Nuclear Energy. https://www.gov.scot/policies/nuclear-energy/ (Accessed on 25/04/2020)

Toke, D. (2005). Explaining wind power planning outcomes: some findings from a study in England and Wales. *Energy Policy*, 33(12), 1527-1539. https://doi.org/10.1016/j.enpol.2004.01.009

Upham, Paul, Oltra, C., and Boso, À. (2015). Towards a cross-paradigmatic framework of the social acceptance of energy systems. *Energy Research and Social Science*, 8, 100–112. https://doi.org/10.1016/j.erss.2015.05.003

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, 35(5), 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

van der Horst, D., and Toke, D. (2010). Exploring the landscape of wind farm developments; local area characteristics and planning process outcomes in rural England. *Land Use Policy*, 27(2), 214–221. http://doi.org/10.1016/j.landusepol.2009.05.006

Wilson, G. A., and Dyke, S. L. (2016). Pre- and post-installation community perceptions of wind farm projects: the case of Roskrow Barton (Cornwall, UK). *Land Use Policy*, 52, 287–296. http://doi.org/10.1016/j.landusepol.2015.12.008

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy*, 21(1), 49–64. http://doi.org/10.1016/S0960-1481(99)00130-5

Wolsink, M. (2018). Social acceptance revisited: gaps, questionable trends, and an auspicious perspective. *Energy Research and Social Science*, 46, 287–295. http://doi.org/10.1016/j.erss.2018.07.034

Wüstenhagen, R., Wolsink, M., and Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. http://doi.org/10.1016/J.ENPOL.2006.12.001

7. Conclusion

7.1. Key conclusions of the thesis

The overarching aim of this thesis has been to provide an in-depth understanding of how public acceptance of RE in GB can be described, understood and explained. It has achieved this by conducting secondary data analysis of two overlooked datasets, the REPD and the PAT, as well as an in-depth case study of Cleve Hill Solar Park. This combination of research approaches has allowed both breadth and depth of analysis in terms of describing trends in public acceptance at both socio-political and community levels. Collectively, these analyses form a rich description of observed trends in public acceptance of RE in different contexts and at different scales in GB.

Specifically, the thesis has addressed three research questions. The first research question asks: *What are the key determinants shaping public acceptance of RE in GB?* This responds to a gap in the existing literature relating to the integration of disciplinary perspectives to provide a holistic synthesis of determinants. This question was answered by identifying determinants for onshore wind and solar farms in terms of community acceptance, and wind, solar, bioenergy and wave/tidal in terms of socio-political acceptance. A key conclusion is that public acceptance of RE is shaped by a wide range of determinants relating to RE *infrastructure* (project details, construction, process), the *impacts* of infrastructure (aesthetic, environmental, economic, social), and the *individual* (demographics, environmental attitudes, temporal/geographical context, views on energy system). These insights are synthesised in the three 'I' framework for public acceptance of RE (Figure 19). The three 'I' framework represents the thesis' main theoretical contribution.

A key advantage of the three 'I' framework is that it integrates a range of disciplinary perspectives including energy geography, energy justice, environmental psychology and ES as well the wider public acceptance literature. This enables it to capture determinants which stem from a wide range of conceptual backgrounds and academic traditions, thus facilitating a broader and more integrated approach to energy governance. It also provides greater detail on specific categories of determinants than existing theoretical frameworks and has been shown to have explanatory value through empirical testing throughout the thesis. Its accessible and visual character means that it could easily be drawn upon by policymakers to better understand determinants shaping public acceptance of RE in a variety of contexts.

The second research question asks: *To what extent does public acceptance of RE (community and socio-political) influence RE decision-making in GB?* This responds to a knowledge gap on how public acceptance actually bears influences over RE decision-making in different contexts. The thesis' findings demonstrate that influence is found to vary between dimensions of acceptance and political context (Table 10). Community acceptance is found to have some effect on local planning and in some cases national policymaking, though not on national planning. The findings suggest that community acceptance is more likely to influence policymaking when there is a wider political benefit to decision-makers. Socio-political acceptance is found to have limited influence on decision-making, creating a divergence between public and policymakers, though slightly more so in the context of the Scottish and Welsh Governments compared to the UK Government. This may suggest the devolved governments are more responsive to public opinion. If this divergence between public and policymakers is not addressed, this may give rise to more frequent protest and 'uninvited' forms of public engagement in energy transitions such as the 'Save Graveney Marshes' campaign discussed in Chapter 5.

The third research questions asks: *What are the implications of the above findings for GB's low carbon energy transition?* It makes recommendations on how sensitive planning and project design, community benefit funds and inclusive, deliberative decision-making processes could help to increase public acceptance and improve the distribution of costs and benefits of RE. It also suggests how measurement of public acceptance could be improved upon by moving away from assumption of NIMBYism and the 'social gap' towards more commensurable measurements of community and socio-political acceptance. It argues this would help policymakers to design and implement RE transitions that are sensitive to public preferences.

7.2. Limitations and further research

There are several limitations to the research presented in this thesis which are important to acknowledge. Firstly, there are limitations to the assumption made in Chapter 3 that planning outcomes are a direct measure of community acceptance. For example, Waldo (2012) identifies that negative feelings or attitudes to offshore wind power in Sweden does not necessarily lead to someone being an active opponent of offshore wind projects. He therefore proposes the idea of 'limits to passivity' referring to the threshold at which feeling/cognition transfers into action, which he suggests varies from individual to individual. This demonstrates that not all members of a community are equally likely to engage in planning processes. Community acceptance measured by engagement with planning processes is thus inevitably a partial view, as certain views will be filtered out (see Figure 25). This is particularly true in the case of NSIPs, for which members of the public must register themselves as 'interested parties' before a fixed deadline in order to formally engage with the planning process: a process which is likely to exclude many people. Further research could engage with informal responses such as those on social media which have a lower 'barrier to entry' to capture a wider body of feelings from the public.

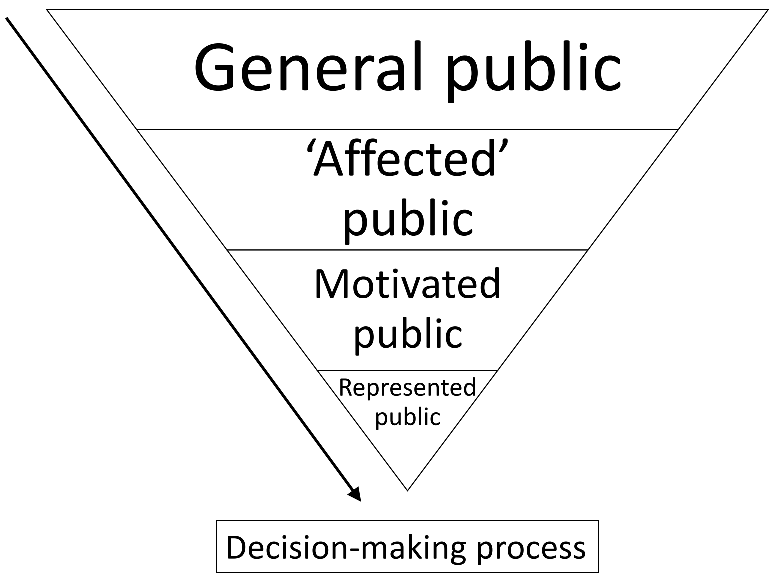

Figure 25. Process by which public views are filtered into decision-making processes

Furthermore, public acceptance itself cannot directly influence a planning outcome; it must also relate to a 'material planning consideration' which means the public may choose to frame their views in certain ways. It could also be that the material planning consideration *itself* influences an outcome, rather than public raising that concern. Thus, planning outcomes should only be seen as a proxy for community acceptance. Further research could focus on the planning decision-making process for specific cases to investigate the role public acceptance has on outcomes, and the extent to which RE planning outcomes do genuinely reflect community preferences.

Secondly, there are limitations to the geographical data that were used in the thesis's analysis, primarily in relation to the PAT. Geographical data on PAT survey respondents were made available at the regional level, although the data is in fact held for respondents at a postcode level (see Appendix 2 for the ONS application). British regions are relatively large spatial areas (for example, Scotland is treated as a single region under this categorisation) meaning that many geographical nuances are consequently obscured. Using this scale as a measure of people's familiarity with RE infrastructure is also limited as it assumes that people do not move extensively beyond the region in which they are based. If more disaggregated data were made available, future research could extend the modelling presented in Chapter 4 of this thesis to better understand how spatial variables may be associated with public attitudes to RE. More geographically disaggregated data on the locations of individuals commenting positively or negatively on RE planning proposals would also be a useful extension to the modelling presented in Chapter 3 of the thesis.

Thirdly, there are limitations to the conclusions drawn in relation to community acceptance of large-scale solar farms based on Cleve Hill Solar Park as a case study. This is because that given its scale (the second largest ever to be proposed in GB), it is an extreme case rather than a representative one. Therefore, not all of the issues identified in relation to this project will necessarily apply to other projects. Indeed, many of the determinants identified were deeply connected to the geographical context of the Cleve Hill proposal. Similarly, the broader conclusions drawn in relation to public acceptance of RE across the empirical chapters of this thesis specifically relate to the geographical context of GB and therefore may not necessarily apply in the same way in other countries. The three 'I' model could therefore be helpfully applied in different geographical contexts to understand differences and similarities in public acceptance of RE in different spaces and places.

Fourthly, the observational research design utilised in this thesis means the findings predominantly apply to centralised, privately owned RE because this is currently the dominant mode of deployment in GB. If an experimental design were to be adopted, or case studies focused on that differed from this business model, further insights could be gained as to whether the thesis's findings apply beyond this type of RE. This too represents a potentially useful extension to the research presented in this thesis.

Finally, further research could usefully delve further into some of the questions raised by this thesis in relation to public acceptance and RE decision-making. For instance, as previously noted, the Scottish and Welsh Governments appear to be more responsive to socio-political acceptance which would be interesting to explore further. Further geographically contextual and political-science informed analysis would be beneficial here, exploring the role of politics, devolution and the rise of populism in various contexts on RE decision-making. Section 6.2 of the thesis hypothesises that socio-political acceptance may have a small influence on local planning by virtue of less social stigmatisation being attached to RE technologies that are widely accepted at the socio-political level. This could be investigated further to ascertain whether there is merit to this hypothesis, and in relation to technologies other than onshore wind and solar farms. Additionally, as raised in Chapter 3, there is scope for further critical and ethical consideration of the extent to which public acceptance *should* influence decision-making from a normative perspective. This would benefit from further exploration from a political science or political philosophy perspective, particularly in the context of a rise in populism and a shift towards global politics which is increasingly reactive to public opinion. Indeed, as the challenge of delivering net zero emissions deepens, and policy responses touch ever closer upon people's lives, how the public respond to low carbon interventions is likely to become an ever more pertinent consideration in the future.

7.3. References

Waldo, Å. (2012). Offshore wind power in Sweden-A qualitative analysis of attitudes with particular focus on opponents. *Energy Policy*, 41, 692–702. https://doi.org/10.1016/j.enpol.2011.11.033

Appendices

Appendix 1. Supporting information for Chapter 3

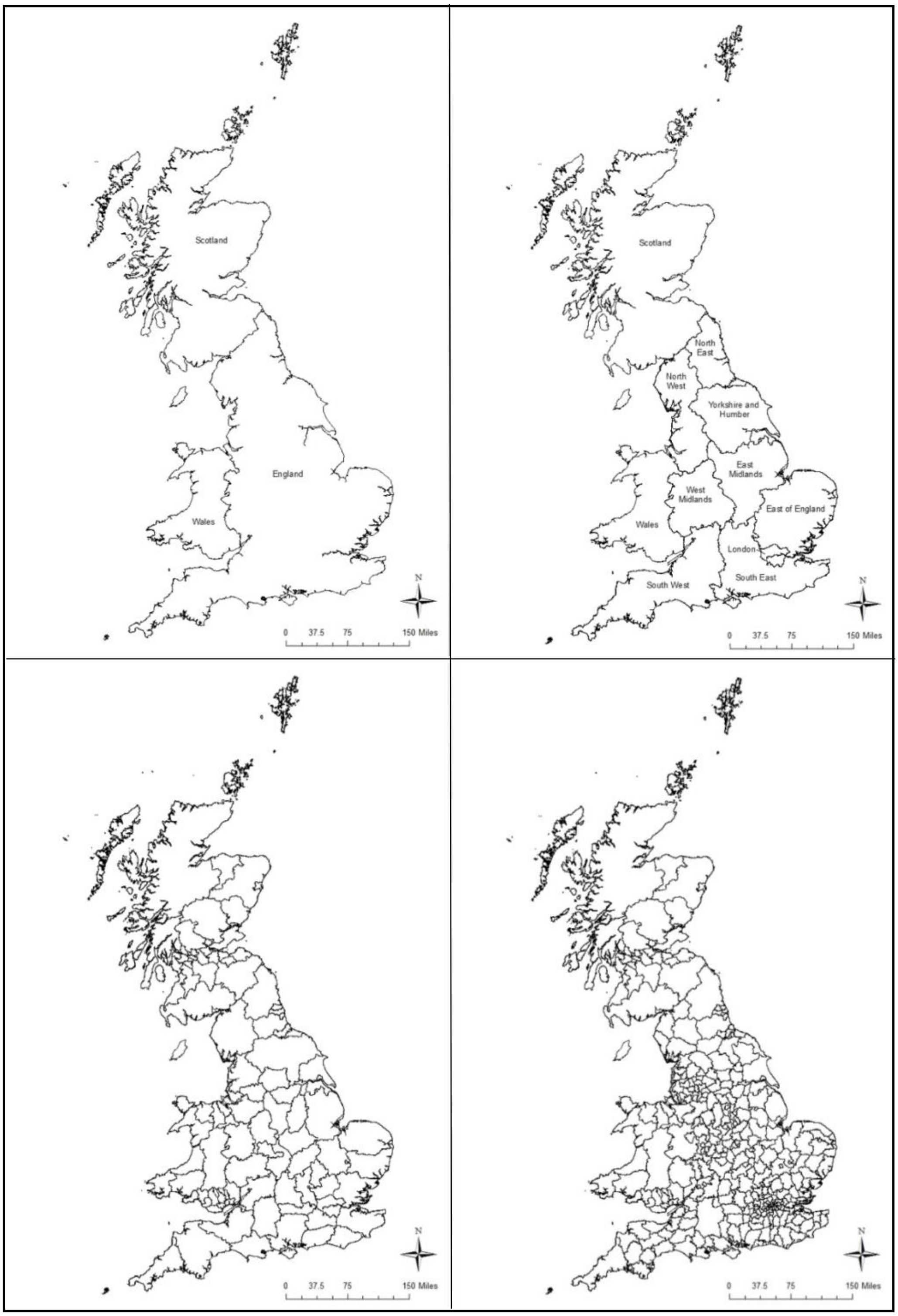

Figure 26. Administrative units of Great Britain: countries (top left), regions (top right), counties (bottom left), and Local Authority Districts (LADs) (bottom right)

Appendix 2. Supporting information for Chapter 4

For our first hypothesis on the familiarity effect, to estimate visual exposure to energy infrastructure we calculated the number of operational sites of each energy source in the respondent's region in the year of the PAT survey. We then used viewshed analysis techniques (commonly applied in geographical disciplines and environmental planning) to calculate the percentage of each region where these sites could theoretically be seen, taking account of the intervening terrain and the average height of that type of infrastructure. First, we collated georeferenced point data for each source in the study: renewable energy (in general), onshore wind, biomass, offshore wind, wave/tidal, solar, nuclear, and fracking. For biomass, we included all types of bioenergy technology in the UK Renewable Energy Planning Database (REPD): Advanced Conversion Technologies; Anaerobic Digestion; Biomass (co-firing); Biomass (dedicated); Energy from Waste Incineration); Landfill Gas; Sewage Sludge Digestion. For solar, we separated ground-mounted solar and rooftop solar given they have very different visual profiles. For fracking, we included all onshore oil and gas sites as they are the most similar type of infrastructure available for comparison, given the limited fracking developments currently in the study area.

Next, we disaggregated the data for each year of the study period (2012-2018), so that the results of the viewshed analysis would reflect the year that the PAT respondent was surveyed. This was important given the rapid deployment of renewable energy technologies over this time period, meaning a viewshed map of onshore wind turbines in 2012 might be quite different to that in 2018, for example. We only included sites that were operational in any given year in order to minimise uncertainty that projects had been proposed but not yet built, and because we regard operational projects as the most appropriate way to measure familiarity (as opposed to proposed projects or projects under construction, for example).

We plotted the georeferenced data on energy infrastructure in a Geographical Information System (GIS) (QGIS Version 2.18.2). We then imported a Digital

Elevation Model (DEM) for Great Britain at a 50m resolution. This provided the GIS with information on the terrain of the study area, so that the visibility of energy projects could be assessed taking this into account. We estimated the average height of different energy technologies from a range of sources (Table 11), and assumed an average visibility distance of 15km based on Bishop (2002). We ran binary viewshed analyses for each technology for each year between 2012 and 2018, using the locations of the energy infrastructure as 'observer' points (see Figure 27 for an example). This produced raster layers in which each pixel is assigned a value for whether the technology can be seen in that location (1) or can't be seen in that location (0). Using boundary shapefiles for each region of Great Britain, we then ran zonal statistics to calculate the percentage of each region (in terms of pixels) where each type of energy source could theoretically be seen in any given year. This analysis does not take account of intervening structures such as buildings and trees which may interrupt a viewer's line of sight, meaning our results should be interpreted only as general estimates of visibility (Table 12).

Table 11. Data sources for georeferenced data on energy infrastructure in Great Britain, and their estimated average heights.

Energy technology		**Estimated average height**	**Sources for georeferenced data**
Onshore Wind		75m	UK Renewable Energy Planning Database (REPD), monthly extract April 2018
Biomass		50m	UK REPD
Offshore Wind		100m	UK REPD
Wave/Tidal		2m	UK REPD
Solar	Solar farm	2m	UK REPD
	Rooftop	5m	UK REPD
Nuclear		50m	Digest of UK Energy Statistics (DUKES) 2017
Fracking		40m	UK Oil and Gas Authority, Onshore Wells 2018

Table 12. Minimum and maximum percentages of regions of Great Britain where energy infrastructure is estimated to be visible between 2012 and 2018.

	Renewable energy (general)		Onshore wind		Biomass		Offshore wind		Wave and Tidal		Solar (rooftop /ground)		Nuclear		Onshore oil and gas wells	
	Min %	Max %	Min %	Max %	Min %	Max %	Min %	Max %	Min %	Max %	Min %	Max %	Min %	Max %	Min %	Max %
North East	34.5	45.5	19.7	39.6	19.2	22.3	2.4	5.0	0.0	0.0	0.0	4.8	2.3	2.3	3.2	3.2
North West	42.1	51.3	14.5	30.2	30.3	33.6	1.2	1.5	0.0	0.0	0.0	11.0	1.3	1.3	9.7	11.3
Yorkshire / Humber	41.0	55.5	15.8	35.1	26.6	41.8	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	15.4	20.9
East Midlands	45.3	68.3	16.7	43.5	28.6	50.4	1.0	1.0	0.0	0.0	4.2	29.1	0.0	0.0	22.4	25.1
West Midlands	30.3	44.0	1.4	7.3	28.5	35.1	0.0	0.0	0.0	0.0	0.3	13.7	0.0	0.0	0.5	1.0
Eastern England	51.1	70.3	11.0	37.8	41.7	50.8	1.2	1.3	0.0	0.0	2.0	25.6	0.9	0.9	0.0	0.0
London	54.1	65.7	13.3	26.2	53.8	64.6	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
South East	35.1	50.3	3.1	10.9	29.8	35.5	0.3	1.0	0.0	0.0	2.6	23.2	0.9	0.9	10.4	12.3
South West	21.9	42.3	4.4	12.7	14.0	19.5	0.0	0.0	0.0	0.0	4.6	27.4	0.7	1.6	1.8	2.5
Wales	21.8	32.7	11.3	23.3	5.8	8.2	0.5	0.6	0.0	0.0	0.3	10.0	0.2	0.2	0.0	0.0
Scotland	18.7	27.7	10.3	25.2	4.6	5.6	0.0	0.2	0.0	0.1	0.0	0.6	0.4	0.4	0.1	0.1

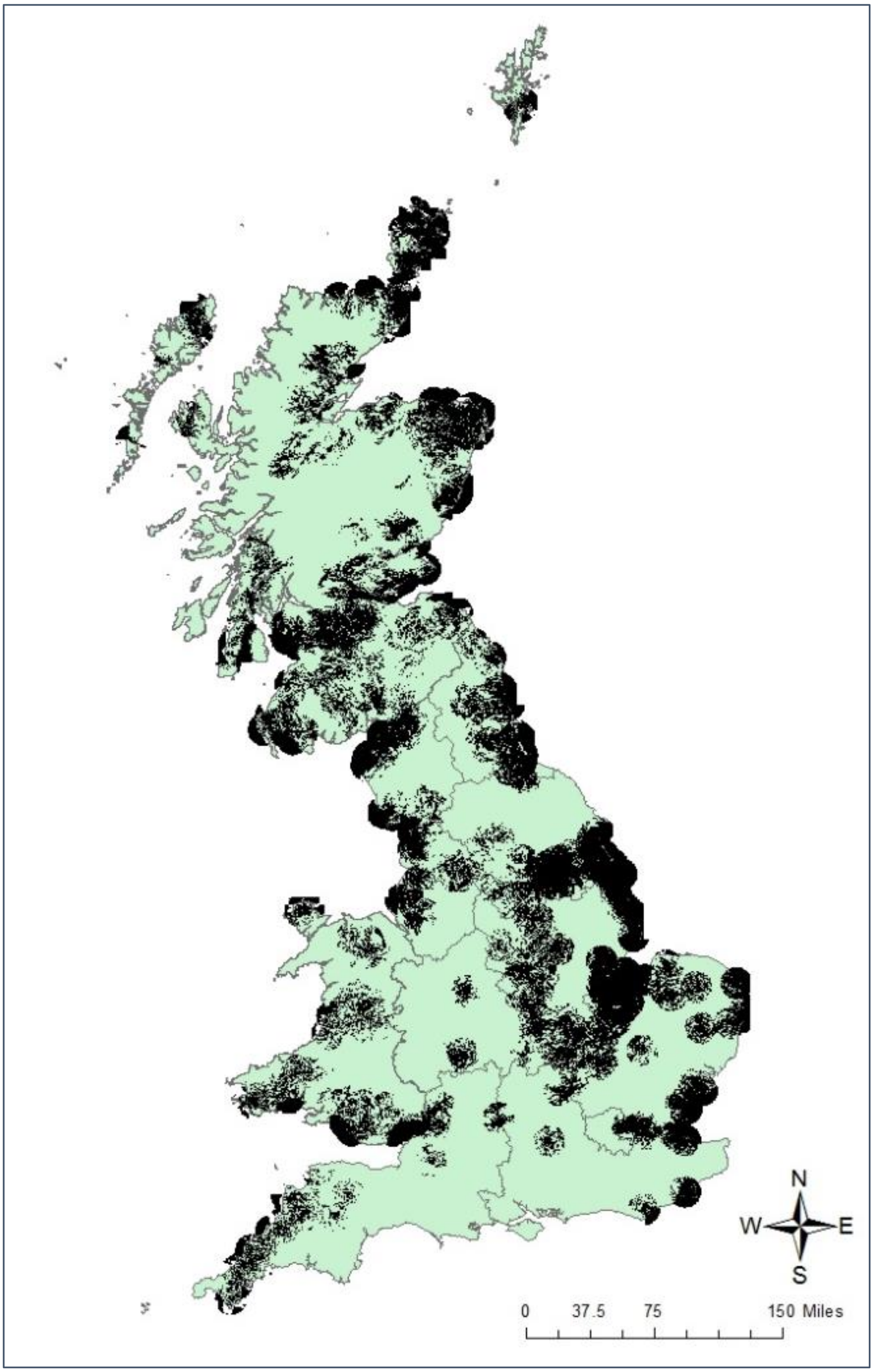

Figure 27. Example of a binary viewshed map: estimated visibility of operational onshore wind farms in 2018 (using the centroid of each wind farm in the UK Renewable Energy Planning Database). Black areas show where turbines are theoretically visible, assuming an average turbine height of 75m and a visibility distance of 15km.

For our second hypothesis on demographics, data on the respondents' age group, gender and social grade were obtained directly from the PAT. Concern for climate change, for our fifth hypothesis, was also obtained in this way. It should be noted that social grade is not the same as social class, but was used as a proxy measure. This is a composite measure comprising occupation, educational qualifications, employment status, and tenure (Lambert and Moy, 2013). It is calculated using the ONS Approximated Social Grade methodology, based on the National Readership Survey methodology. It assigns respondents into 6 economic classification groups: A, B, C1, C2, D and E. Whilst we regard this as the most appropriate measure to use given data availability, we acknowledge the limitations and complexities of using indirect indicators in social science research (Connelly *et al*., 2016).

As the PAT does not collect data on the political orientation of its respondents, regional aggregates of political support had to be used for our third hypothesis. Data on political representation for each parliamentary constituency in Great Britain was obtained from the UK Electoral Commission website, and the most recent election data was used to assign a percentage to each region of constituencies represented by the UK Conservative Party. Whilst other political parties also identify as politically conservative, we regard this as the most succinct way of measuring conservatism given the very substantial role of the UK Conservative Party in British politics.

For our fourth hypothesis on employment in the energy industry, we obtained data on direct employment in the renewable energy industry from the Renewable Energy Association, the nuclear industry from the Nuclear Industry Association, and onshore oil and gas from Oil and Gas UK. We then calculated these figures as a percentage of total regional employment, using the UK Labour Force Survey (A07: Regional Labour Market Summary) to estimate regional employment in each energy sector.

Table 13. Odds ratios for the independent variables included in the ordinal regression models predicting support for energy sources. Figures in bold show statistically significant effects ($p < 0.05$).

	Renewable energy		Onshore wind		Biomass		Offshore wind		Wave and Tidal		Solar		Nuclear		Fracking	
	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO	SvNO	SNvO
% region where energy technology is visible	0.994		1.001	1.003	1.001	0.999	1.027		**0.100**	1.287	0.993	0.995	1.011		0.996	1.003
Urban area (vs rural area)	0.895		**1.259**	1.133	0.961		1.062	1.026	0.779		0.961		1.093		1.001	**1.197**
Year of PAT survey	**1.054**		1.014	**1.057**	0.999	1.018	1.022	**1.088**	1.019	1.053	1.053	1.064	0.976	**0.961**	**0.852**	**0.824**
Age 16-24 (vs 65+)	**2.612**		**4.739**	**2.565**	**1.627**	**1.548**	**3.558**	**1.835**	1.119	1.219	**2.785**		**0.785**	**0.537**	**1.476**	**0.649**
Age 25-34 (vs 65+)	**2.142**		**4.473**	**2.859**	**1.715**		**3.748**	**2.316**	1.300		**3.541**	**3.273**	0.864	**0.533**	1.057	**0.528**
Age 35-44 (vs 65+)	**2.600**		**3.306**	**2.423**	**1.586**		**3.728**	**2.463**	**1.450**		**3.051**		**0.667**	**0.514**	0.856	**0.586**
Age 45-54 (vs 65+)	**2.096**	**1.955**	**2.353**	**2.272**	**1.563**		**2.287**		**1.597**		**2.291**		**0.711**	**0.581**	**0.790**	**0.571**
Age 55-64 (vs 65+)	**1.804**	**1.949**	**1.523**		**1.374**		**1.532**		0.982		**1.367**		**0.829**		**0.724**	
Male (vs female)	**0.762**	1.274	**0.737**	1.121	**0.741**	1.087	**0.698**	**1.293**	**0.757**	**1.475**	0.858	1.174	**1.307**	**2.483**	**1.111**	**1.937**
Social Grade A (vs E)	1.317		**0.601**	0.972	0.857	1.455	0.786	1.243	1.443	1.696	1.164	1.525	**1.858**	**2.514**	**1.377**	**2.179**
Social Grade B (vs E)	**1.493**	**1.662**	**0.755**	1.122	0.870	1.314	0.854	1.335	**1.601**	**1.967**	1.030	1.260	**1.309**	**1.714**	**0.829**	**1.364**
Social Grade C1 (vs E)	1.168	1.287	0.809	1.078	0.907	1.205	0.854	1.227	**1.629**		1.185	**1.398**	**1.335**		0.896	**1.189**
Social Grade C2 (vs E)	0.905		0.906	0.939	0.863	1.053	0.928	1.022	1.221		1.044		**1.174**		1.051	
Social Grade D (vs E)	0.914		0.895	0.854	0.867		0.938	0.885	1.047	0.977	0.866		1.133		**1.274**	**1.230**
% UK Conservative Party MPs in region	**1.017**		**1.009**	**1.008**	1.005	1.009	1.001		0.997	1.002	1.001	1.011	**1.009**		1.003	
% energy jobs in related energy sector in region	0.544		**3.519**	0.616	2.485	1.959	1.870	**0.191**	0.242		1.222	0.883	1.103		**0.375**	
Very concerned re: climate change (vs not at all)	**2.298**	**4.807**	**2.147**	**3.526**	**1.785**	**2.812**	**2.391**	**4.203**	**1.924**	**3.489**	**1.920**	**5.696**	**0.506**	0.851	**0.416**	**0.648**
Fairly concerned re: climate change (vs not at all)	**2.453**	**3.781**	**2.326**	**2.501**	**2.183**		**2.765**	**3.186**	**2.354**	**2.515**	**1.761**	**3.256**	1.008	1.072	**0.819**	
Not very concerned re: climate change (vs not at all)	**1.733**		**1.383**		**1.542**		**1.652**		**1.643**		1.276	**1.710**	1.140	1.068	0.973	
Psuedo R^2 (Nagelkerke)	0.17		0.17		0.8		0.19		0.13		0.18		0.11		0.13	
No. responses (once subsetted)	11,410		29,436		15,157		17,485		8,668		11,620		38,142		37,801	

Table 14. Installed capacity of the eight energy sources in this study within each region of Great Britain in April 2018, and their rankings in relation to each other. For fracking, number of spuds (i.e. drill holes) is given instead of megawatts (MW). Data is from the April 2018 monthly extract of the UK Renewable Energy Planning Database (REPD); Digest of UK Energy Statistics (DUKES) 2017; Oil and Gas Association (OGA) Onshore Wells (OGA Open Data, accessed 30/05/2018).

Region	Renewable energy		Onshore Wind		Biomass		Offshore Wind		Wave / Tidal		Solar		Nuclear		Fracking	
	MW	Rank	MW	Rank	MW	Rank	MW	Rank	MW	Rank	MW	Rank	MW	Rank	Spuds	Rank
North East	906.1	9	469.6	4	279.0	6	107.6	8	0	3	49.8	10	1210	4	0	2
North West	2426.3	7	467.0	5	432.1	2	1344.2	3	0	3	183.1	8	2400	2	7	1
Yorkshire/Humber	4207.3	3	642.8	3	2946.3	1	429.0	6	0	3	189.2	7	0	8	0	2
East Midlands	2349.4	8	403.9	7	234.9	9	750.9	4	0	3	959.7	4	0	9	0	2
West Midlands	683.8	10	6.5	11	239.0	7	0.0	9	0	3	438.3	6	0	10	0	2
Eastern England	4348.3	2	441.2	6	386.8	4	2107.3	1	0	3	1413.0	3	1188	5	0	2
London	258.3	11	12.6	10	237.7	8	0.0	10	0	3	7.9	11	0	11	0	2
South East	3508.2	4	104.1	9	417.6	3	1469.5	2	0	3	1516.9	2	1110	6	0	2
South West	3004.7	5	274.8	8	197.4	11	0.0	11	23	1	2509.5	1	1220	3	0	2
Wales	2717.3	6	1021.4	2	214.1	10	726.0	5	0	3	755.8	5	980	7	0	2
Scotland	8126.2	1	7484.1	1	341.1	5	221.0	7	11	2	69.0	9	2440	1	0	2

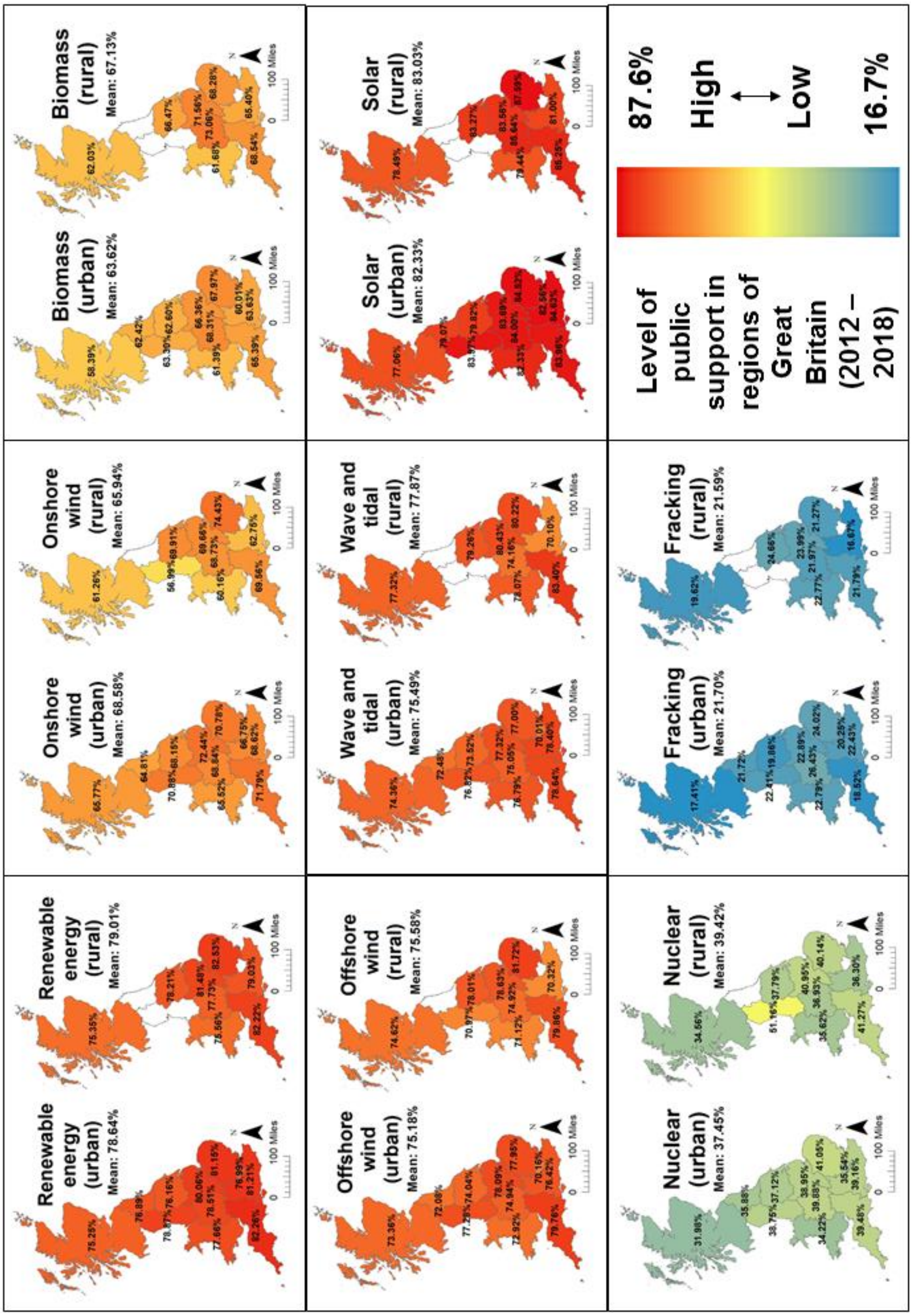

Figure 28. Support for energy sources in regions of Great Britain (2012 – 2018), separated into survey respondents living in urban and rural areas according to ONS urbanisation criteria. Shetland Islands have the same results as the rest of Scotland. White areas had too few responses to ensure confidentiality of survey respondents (< 10). Data is from the UK Government's Energy and Climate Change Public Attitudes Tracker (Waves 1 – 25). All statistical results remain Crown Copyright.

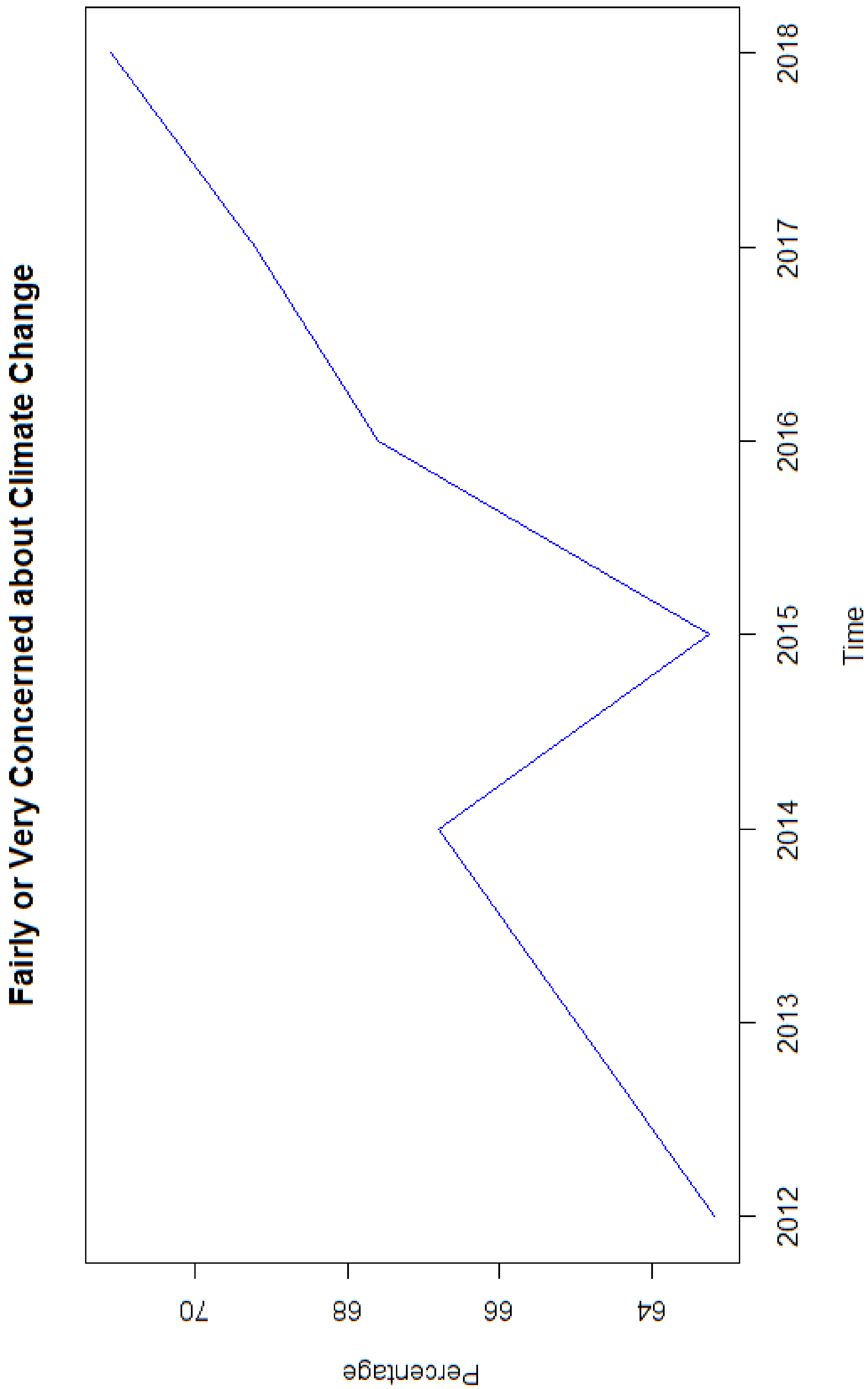

Figure 29. Percentage of UK population that are fairly or very concerned about climate change from 2012 to 2018. Data is from the UK Government's Energy and Climate Change Public Attitudes Tracker (Waves 1 – 25). All statistical results remain Crown Copyright.

1 Lead Researcher:

1.1 Personal details and contact information of lead researcher

Surname*	Ziv		
First Names*	Guy		
Do you have an AR Number?		No	AR Number:

1.2 If you do not have an Accredited Researcher Number, please complete the following section.[5]

Institution or Organisation	University of Leeds
Full Address	Room 10.26, Garstang Building, School of Geography, University of Leeds, Leeds, LS2 9JT, UK
Telephone No	0113 3437994
Email	G.Ziv@leeds.ac.uk
Date of Birth	05/03/1978
Nationality	Israel

2 Researcher Team:

2.1 If you are leading a research team, please provide the names and details of all members of the team. Please add more tables if required.

Surname*	Roddis		
First Names*	Philippa		
Do you have an AR Number?		No	AR Number:

2.2 If the researcher does not have an Accredited Researcher Number, please complete the following section.

Institution or Organisation	University of Leeds
Telephone No	07821329170

[5] *To become an Accredited Researcher, please complete the Accredited Researcher application form on:* https://www.ons.gov.uk/aboutus/whatwedo/statistics/requestingstatistics/approvedresearcherscheme

Email	P.Roddis1@leeds.ac.uk
Date of Birth	19/04/1989
Nationality	British

3 Research Sponsor:

3.1 *Are you carrying out this project on behalf of a third party organisation?*

Yes

3.2 *If you are working on behalf of a third party organisation, please provide the details of this organisation below;*

Sponsor	Natural Environment Research Council (ADVENT project)
Institution or Organisation*	Natural Environment Research Council
Address	Polaris House, North Star Avenue, Swindon, SN2 1EU, UK
Telephone No	01793 411500
Email	researchgrants@nerc.ac.uk

4 Title of the research proposal:*

Exploring public acceptance of renewable energy using the UK Energy and Climate Change Public Attitudes Tracker

5 Abstract of the research proposal:*

Please include a short description of the project and its benefits,

Explaining public attitudes and preferences for renewable energy is important in terms of understanding public acceptance of energy and climate change policies. This research will use data from the UK Energy and Climate Change Public Attitudes Tracker to explore factors contributing to positive and negative attitudes towards renewable energy sources. This research will provide insights relevant to energy policymaking by highlighting implications for the UK's delivery of climate and energy policy objectives.

6 Details of Research Proposal:

Please provide a detailed description of the purpose for which the data are requested, describing the aims of the study/research. Where research is part of a larger programme, please include details below.

This research is part of the Addressing Valuation of Energy and Nature Together (ADVENT) project, funded by the Natural Environment Research Council. It explores the implications for ecosystem services and natural capital of future UK energy pathways. The data is requested for the PhD research of Philippa Roddis, who is funded by the ADVENT project. Her PhD is

investigating public acceptance of renewable energy in the UK, in particular focusing on onshore wind and solar farms.

7 Data Required[6]:

7.1 Please provide the title(s) of the dataset(s)[7];

Micro-data on respondents to the Energy and Climate Change Public Attitudes Tracker, including geographic location. Please note that the release of this data has been agreed with BEIS (lead: Orkid Russel) who we understand is in the process of uploading it to the VML. We are aware that some microdata on respondents to the Tracker is publicly available, though without geographical location attached.

7.2 Please explain why access to legally protected data is needed? Please state what other data sources have been considered, and why they are not sufficient for your purposes.

Geographical data is of importance to understanding the relationship between the location of renewable energy infrastructure and public attitudes towards it. There is no alternative georeferenced dataset providing this information at the UK scale other than the Energy and Climate Change Public Attitudes Tracker.

7.3 Does your project proposal include any linking of data sources?

Yes

If answered yes, please provide details below;

UK Census, Renewable Energy Planning Database

8 Public Good:

8.1 Please tick one or more of the following 'Public Good' criteria that your project will meet;

☐	To provide an evidence base for public policy decision making
☐	To provide an evidence base for public service delivery;
☐	To provide an evidence base for decisions which are likely to significantly benefit the UK economy, society or quality of life of people in the UK;
☐	To replicate, validate or challenge Official Statistics;

[6] If the applicant requests access to ONS Longitudinal Study data sets, they must complete the appropriate supplementary form on the ONS website.
[7] If the applicant requests access to data within the Virtual Microdata Laboratory, they should refer to the VML Data Catalogue on the ONS website for this section.
https://www.ons.gov.uk/aboutus/whatwedo/statistics/requestingstatistics/approvedresearcherscheme

▭	To replicate, validate or challenge existing research;
X	To significantly extend understanding of social or economic trends or events by improving knowledge or challenging widely accepted analyses; or
X	To improve the quality, coverage or presentation of existing statistical information.

8.2 *Please describe how your project meets the criteria you have chosen;*

Our project will significantly extend understand of social trends around public attitudes to renewable energy by elaborating on the existing statistical analysis conducted by BEIS. It will improve the quality of the existing statistical information by including geographical data, which has not currently been investigated (to the best of our knowledge).

9 Duration of access:

Please indicate how long access to data is likely to be required;

30 September 2020 (conclusion of Philippa Roddis's PhD study period)

10 Publications:

ONS expects that research undertaken through the Approved Researcher Scheme will be published, other than in exceptional circumstances.

10.1 *Do you intend to publish the results of your project once research is completed?*

Yes *If no, please skip to question* ***10.5***

10.2 *How will you make the results of your research available?*

It will be available in Philippa Roddis' PhD thesis which is to be a public document.

10.3 *Where do you plan to publish your analysis/results?*

We also plan to publish our analysis in a scientific journal and a publicly accessible website such as The Conversation.

10.4 *Please provide an estimated timescale for publication;*

Mid-2019/early-2020

10.5 *Please explain the exceptional circumstances for not publishing your results once the project is complete. Please note that refusing to publish your research outputs may result in a rejection of your project application.*

N/A

Appendix 3. Supporting information for Chapter 5

Table 15. Description of 28 determinants of community acceptance of Cleve Hill Solar Park. Signs refer to whether code is used to support or oppose the project.

Category	**Code**	**Meaning**
Aesthetic	Visual impact	The impact of the solar farm infrastructure on available views of and from the site (-)
	Landscape character	The character of the existing landscape on the site i.e. greenfield, rural, open skies, marshes (+/-)
	Glint and glare	Unwanted reflection of the sun's rays off the surface of the PV panels (-)
Environmental	Wildlife and habitats	The impact of the solar farm on wildlife and habitats, including nature reserves and protected areas for biodiversity e.g. SSSIs, SPAs (+/-)
	Flooding	Increased flood risk due to the site no longer being managed by the Environment Agency, used as a flood plain or for coastal realignment (-)
	Carbon	Carbon saved by reducing fossil fuels (+); carbon emitted in construction and maintenance (-); impact on ability of the site to sequester carbon (-)
Economic	Agriculture	Impact on ability to use land for agriculture (e.g. grazing, growing crops) (-)
	Tourism	Impact on tourism to the area and effect on the local economy (-)
	Jobs	Employment created through construction, operation and maintenance (+/-)
	Property values	Impact on the value of nearby properties and people's ability to sell their homes (-)
Project details	Project scale	The amount of land used (-); capacity of the project (in terms of electricity output) (-); the height of the solar panels (-)
	Design	The density and east-west orientation of the PV panels (-)
	Technology	Utility of battery storage (+); concerns around battery storage e.g. fire risk (-); anticipated obsolescence of current PV and battery technology (-)
	End-of-life	Decommissioning concerns e.g. hazardous waste, site restoration (-)
	Business model	Private ownership by a commercial company (-); lack of direct community benefits including the electricity produced not being consumed locally (-)
Temporal	Heritage	Impact on the cultural heritage of the area e.g. archaeology, boating (-)
	Legacy	Impact on bequest value of the area and availability for future generations (-); responsibility to tackle climate change for future generations (+)
Social	Health and well-being	Impact on physical and mental health of the community (from construction impacts and the loss of greenspace for exercise and relaxation) (-)
	Recreation	Impact on the ability of people to use the site for recreational purposes such as walking, cycling and birdwatching (-)
	Place attachment	Expression of love, emotional bond or strong affection to the site or wider area (-)
Construction	Traffic	Impacts of increased traffic flows, particularly on narrow country roads (-)
	Noise pollution	Noise disturbance caused by construction, operation and maintenance of the facility (-)
	Air pollution	Air pollution from construction and increased traffic flows (-); lower air quality due to loss of greenspace (-)
	Light pollution	Light pollution from construction processes and ongoing security lighting for the site (-)
	Cumulative impacts	Cumulative local impacts alongside other infrastructure developments e.g. housing developments, other energy infrastructure (-)
Process	Trust and transparency	Expression of (mis)trust and (in)transparency from developer and/or planning authority (for NSIPs this is the Planning Inspectorate) (-)
	Mitigation measures	(Dis)satisfaction with mitigation measures proposed for the project's impacts (+/-)
	Alternative options	Perception that other locations are more suitable e.g. rooftops, brownfield sites (-); perceived lack of consideration of alternative locations and/or alternative options for generating electricity or reducing emissions (-)

END