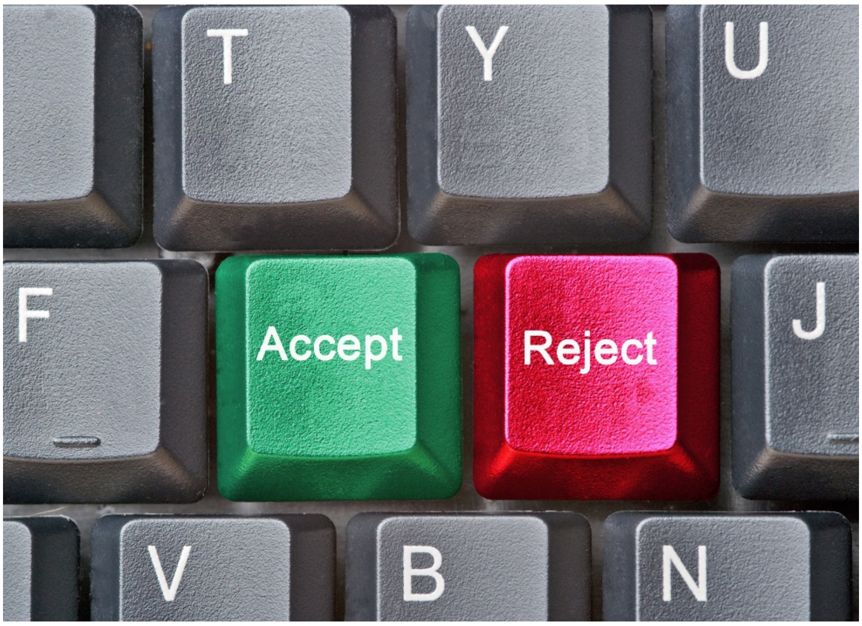
Understanding public responses to low carbon technologies



IN-DEPTH ANALYSIS

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Understanding public responses to low carbon technologies

Strategies for a low carbon transition

This report reviews different models and frameworks that explain public responses to low carbon technologies (LCTs). Based on insights from literature, it highlights the need for a multidimensional perspective to understand the complexities surrounding public acceptance or opposition to LCTs. It also proposes two key solutions for how public responses can be better accommodated in a way that engenders support from the public: by integrating social and values-based aspects in planning, and by ensuring procedural justice in technology deployment. Reflecting on these, policy options are drawn for how these solutions might help contribute to delivering better approaches in engaging the public in the low carbon transition.

AUTHORS

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Executive summary

In line with the Paris Agreement, which requires countries to adopt legally-binding measures to limit global warming to well below 2°C, the EU and its Member States committed to a reduction in greenhouse gas emissions by at least 40 % in 2030 compared to 1990 levels. Achieving this requires widespread deployment of low carbon technologies, however addressing a number of technological, economic, social and policy challenges is central to the successful implementation of the diverse technologies essential to the low carbon transition. Among these challenges, public acceptance and support are often decisive factors impacting successful deployment.

The aim of this report is to is review, and critique, understandings of social responses to renewable and low carbon technologies; it presents an indicative overview of key understandings, not a comprehensive assessment of all the literature in this area. The literature reveals that public responses to low carbon technologies (LCTs) are shaped by factors related to the individual (e.g. their beliefs and values), to the social context (such as engagement and institutions) and to the characteristics of the technologies and their location. We also consider and reflect upon how public responses to LCTs shape, or are shaped by, the different roles conceived for the public within the energy system. From the studies we reviewed, we identified three perspectives taken by models, frameworks, and theories to explain social responses towards LCTs: linear perspectives; frameworks which incorporate multiple factors to explain public attitudes; and multidimensional perspectives.

Frameworks that take a linear perspective such as the knowledge deficit and 'not in my backyard' (NIMBY) models suggest a singular reason for social responses to technology deployment. Whilst a simple explanation which suggests a clear solution, or 'silver bullet' to issues of opposition has been attractive to technology proponents, these framings have been criticised for their narrow view of issues surrounding opposition, and for offering a lack of detailed explanation of public responses to specific technologies. Thus, a broader understanding of public attitudes towards LCT can be gained by using theories from psychology and sociology which demonstrate that public attitudes are influenced by diverse personal, social, psychological and cultural factors..

Multidimensional frameworks take an interdisciplinary perspective to offer a more holistic understanding of the complexities surrounding public attitudes towards LCT. These approaches include frameworks that explain (1) public concerns about visual/landscape, environmental, socioeconomic and procedural aspects (VESPA) of LCT; (2) the **social gap** between high levels of support and low rates of success for LCT schemes; (3) the relevance of **social acceptance**; and (4) the **social licence to operate**, the tacit approval from affected communities for the planning and deployment of low carbon technologies. We found further evidence from recent literature that highlights the importance of values-based factors (shared beliefs, social relationships), the framing and reception of messages about LCTs by stakeholders, issues of justice, fairness and trust, and impact of processes of public engagement and technology deployment in shaping public responses towards LCTs. While these frameworks are not without their critiques, we argue that they allow for a better understanding of public reponses compared to linear models.

Within the studies reviewed, Two key solutions emerged for how the planning and deployment of LCTs could be conducted in order to accommodate and respect public responses, involve the public and engender support for implementation. The first solution highlighted is the integration of social and values-based aspects in planning, to allow for different perspectives (psychological, social, cultural, emotional) to be given space and value within planning processes. Controversy surrounding technology deployment is often manifest at a local scale, within an affected community, however a specific application takes place within a regional, national and international policy context. Thus, participation in planning has to take place at multiple scales, from the local to the national and international. The second solution is to ensure procedural justice in deployment, such that the people and communities which may be affected by deployment of LCTs are involved in fair and equitable processes of decision making. We further propose that this can be supported through processes of learning and collaborative governance amongst all stakeholders – local communities, industry, and policy actors – giving more agency and legitimacy to the public as active participants in low carbon transitions.

Based on these insights, we recommend four actions to support the deployment of renewable and low carbon technologies: (1) publics must be engaged in ways that support deliberative and participative planning approaches; (2) it must understood that outcomes of public engagement may change technology types, scale, and other aspects of deployment. It is (3) important for policy actors to recognise the value of trust that publics place with project implementers and how this might impact support for low carbon technology adoption. Finally, it is (4) important to respond to public concerns in ways that seek to engender support rather than seeking to overcome opposition. This requires thinking about how people interact with, interpret, use and make sense of low carbon technologies.

To support the deployment of renewable and low carbon technologies these actions should be enshrined within policies which place greater emphasis on public engagement at each stage of the policy process from energy planning to the scale of individual projects, and at a local, regional and national scale. Our main recommendations are for: (1) participatory planning approaches to be adopted to engage the public within all aspects of energy planning; (2) impacts and benefits of projects should be assessed using context-specific measures; (3) partnerships must be created with locals and host communities; and (4) policy must provide guidance on the design of effective processes which ensure fairness and build trust

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List of acronyms

CCS	Carbon capture and storage
CCUS	Carbon capture utilisation and storage
EU	European Union
EV	Electric vehicle
HVTL	High voltage transmission line
IPCC	Intergovernmental Panel on Climate Change
LCT	Low carbon technology
NDC	Nationally determined contribution
NIMBY	Not in my backyard
PV	Solar photovoltaic
SLO	Social licence to operate

1. Introduction

1.1. The need for a low carbon transition

In 2015, governments from 196 parties, including the European Union (EU), agreed to adopt the Paris Agreement. This requires countries to commit their best efforts to combat climate change and address its impacts through legally-binding nationally determined contributions (NDCs). Meeting the NDCs requires adopting measures to limit global warming to well below 2°C (UNFCCC, 2015, CP/2015/10/Add.1). The urgent need for action has been further stressed with the recent report of the Intergovernmental Panel on Climate Change highlighting potential catastrophic impacts by 2030 if the world continues on a 'business-as-usual' pathway (IPCC, 2018).

In its NDC, the EU and its Member States committed to reduce greenhouse gas emissions by at least 40 % in 2030 compared to 1990 levels (European Commission, 2015). Achieving this requires widespread deployment of low carbon technologies for electricity generation, heating and transportation (Peters et al., 2017). Currently, renewable energy accounts for 17 % of the EU's total final energy consumption, and the aim is to reach at least 27 % by 2030. In line with this, the EU also aims to transition to a 100 % zero emissions vehicles fleet by 2050 and retrofit coal power plants with carbon capture utilisation and storage technologies (Alves Dias et al., 2018; European Commission, 2014, COM/2014/015; European Environment Agency, 2017; Witkamp et al., 2017). Table 1 summarises the types of low carbon technologies available in the EU, their current contribution, and targets.

Table 1. *Low carbon technologies in the EU*

Gross final energy consumption (%)	Electricity	Heating and cooling	Transport	Current status / contribution	Target
Renewable energy	29.6	19.1	7.1	17 %	27 % by 2030
Wind	30.9	-	-	-	-
Tidal, wave, ocean	0.1	-	-	-	-
Solar PV	11.3	-	-	-	-
Hydropower	38.7	-	-	-	-
Geothermal	0.7	-	-	-	-
Heat pumps		10	-	-	-
Bioenergy	18.4		-	-	-
Solid biomass		83	-	-	-
Biogas		4	-	-	-
Low emissions transport*				7 %	10 % by 2030
Liquid biofuels**	-	-	88.5	-	-
Electric vehicles†	-	-	11.5	-	100 % by 2050
Carbon capture utilisation and storage				3 CCS demonstration plants	up to 12 CCS demonstration plants (previous target in 2015) ‡

Source: EuroStat (2016), European Environment Agency (2018, 2017), EU Energy in Figures 2018 (2018)
Notes: * Computed based on data from EuroStat, 2016; ** Includes non-compliant biofuels
† Includes electricity in road and rail transport; ‡ The 2017 report of on the implementation of the EU Directive on Geological Storage of Carbon Dioxide cite that CCS is not technically and economically feasible for the 29 power plant sites assessed

1.2. Challenges for low carbon energy and transport

Within the EU, the 2017 European Social Survey suggests that there is greater support for renewable energy sources than coal and nuclear (European Social Survey, 2018). Although there are variations between countries, around 80 % of respondents support large and very large amounts of electricity coming from wind, solar or hydro-electric generation. This compares to around 10 % of respondents who wished to see either large and very large amounts of generation from coal and nuclear power. When low carbon technologies (LCTs) are deployed at a local level, however, the practical experience of deployment is often that support for technologies that is expressed in surveys does not translate into project implementation with opposition from host communities, the wider public and stakeholders (See for example Batel, 2018; Giordono et al., 2018).

It is known that deployment of technologies essential for the low carbon transition faces a number of challenges – policy, technological, economic, social (Malone et al., 2017; Roberts et al., 2012; Witkamp et al., 2017). Among these, literature suggests that there are gaps between policy targets and their implementation (Díaz and van Vliet, 2018), conflict between LCT and other environmental goals such as air pollution (e.g. using solid biomass for heat), and less attention given to social sustainability compared to economic criteria (e.g., EU directive on biofuels) (German and Schoneveld, 2012; Landeta-Manzano et al., 2018).

Moreover, publics are key to this transition and will play a number of diverse and distinct roles including as adopters of new technologies in their homes and everyday life, as host communities, as consumers of low carbon energy, citizens, technology proponents and opponents. Social aspects (i.e., public acceptance, Devine-Wright, 2007) can, therefore, become decisive factors in low carbon energy transition even when technologically and economically feasible solutions are available.

Within this review, it is essential to reflect upon the terminology of public acceptance and support for low carbon technologies and also consider how publics and technology shape and are shaped by these interactions and the different roles conceived for publics within energy system change. Batel, et al. (2013) caution that framing research around 'acceptance' of technologies suggests that all people need to do is to accept rather than actively engage and support. This framing potentially also misses opportunities to understand other types of resp0nses that people can have to technology such as uncertainty, support or risk awareness. The diversity of social responses should instead be acknowledged and ideally viewed as a continuum, withheld at one end, passing through acceptance and being viewed positively, ideally reaching a point where a development is supported and welcomed (see for example Thomson and Boutilier, 2011). A narrow conceptualisation of social responses will not only undermine adoption of technology, but can also limit the way in which technologies are used, for example, by enabling consumers to play a more active role in the energy system.

Driven in no small part by a focus on individual technologies in the context of a specific application, public attitudes have usually been explored for individual technologies, and not in relation to the whole-system changes necessitated by the low carbon transition and which are envisaged in national strategies, such as the UK's Clean Growth Strategy or Germany's Energiewende, and within EU policy. Away from the context of a specific application, researchers have started to explore public views of portfolios of energy supply technologies (see for example Demski et al., 2015). Taken as a whole, energy systems comprise of numerous and diverse technologies on both the supply (e.g. wind turbines, PV, nuclear) and demand side (e.g. electric vehicles, appliances), with associated practices and behaviours. Low carbon energy supply technologies operate at a range of scales. Photovoltaic (PV) panels or solar thermal technology can help meet a household's energy needs, whilst at a community level an onshore wind farm or biomass plant may export electricity for thousands of homes via the grid. Large scale renewable projects such as offshore wind farms or, eventually, tidal stream may meet the electricity needs of hundreds of thousands of homes and be remote from the consumers they supply. Some European nations, including the UK, France and Finland, are constructing new nuclear power stations and carbon capture utilisation and storage (CCUS) technology which has the potential to significantly reduce the carbon emissions from fossil fuelled power stations and industrial installations is being actively pursued. Different nations will have different renewable resources, regulatory, governance and institutional regimes which provide the context for the judgements which people make about the acceptability of particular technologies and the overall system transformation.

Table 2 outlines some key issues which have influenced opposition to LCTs. Understanding these issues and underlying processes which affect the social responses, which make opposition more or less likely, is important to enable carefully designed '**public interventions**' which can build support for the low carbon transition and avoid **unnecessary** conflict, at both a societal level and when deployment of a specific technology is proposed.

Table 2. *Key issues for opposition in LCTs*

Low carbon technology	Key reasons for opposition
Renewable energy	
Wind	sound and visual impact, distance from turbines
Tidal, wave, ocean	issues of trust with institutions involved, distribution of benefits
Solar PV	high cost of installation, storage, concerns on efficiency
Hydropower	environmental impacts (e.g., forest destruction), reduce aesthetic value of water streams, potential displacement of communities living near facility
Geothermal	not identified*
Bioenergy (Solid biomass, biogas)	lack of farmer consultation, issues of trust with developers, unwelcomed changes in the farm or community
Low emissions transport	
Liquid biofuels	impact on land use change for communities in the global south
Electric vehicles	inconvenience in finding charging stations (e.g., extra distance needed to travel), extra battery costs
Carbon capture utilisation and storage	concerns over type of power plant the carbon dioxide comes from, concerns on further coal abstraction, unproven nature of CCS, potential environmental impact

Note: *Based on string search via Scopus conducted in October 2018, none of the articles listed focus on public responses to geothermal energy

1.3. Objectives and methods

This review presents key insights into public responses to low carbon technologies and proposes policy options at both an individual project level and for the planning of LCTs at a regional and national scale, which would support engagement with host communities, and wider society. Our key assertion is, firstly that there is a need to understand the reasons for why the public might accept or reject LCTs and secondly, these responses need to be recognised and responded to in ways that build support at a project level, and for the wider transition to a low carbon society. Our aim is to contribute to the debate on appropriate policies and interventions to support the low carbon transition within the EU.

We start with an overview of frameworks and approaches for understanding public responses, focusing in particular on a review of case studies of LCT deployment in the EU conducted within the last 10 years. Whilst our focus is primarily on the EU, we also cite examples from the United States (US) and the Global South which may inform learning about how LCT deployment may be planned and facilitated. It should be noted that the review presented here is not systematic and exhaustive. Instead, we offer a critical review of public responses to LCTs in order to understand how future projects might be implemented or deployed.

In Section 2, we provide an overview of explanatory frameworks which have been proposed for the analysis and understanding of public responses to renewable energy and other low carbon technologies and describe in more detail the factors which sit within those frameworks. Section 3 outlines proposed solutions drawn from the literature on energy and low carbon controversies and in Section 4, we present options for policy-makers.

2. Understanding public responses

There is a diverse literature which sets out potential explanations for public opposition to low carbon technologies (LCTs). However, whilst research in this field is rich in terms of documenting levels of awareness and support for particular technologies, it has been criticised for not providing detailed and theoretically informed analysis and categorisation of explanations of these positions (see for example Devine-Wright, 2007; Petrova, 2016; West et al., 2010). A number of frameworks have been developed and applied to provide insights into public perceptions of renewable energy and other low carbon technologies; here, we provide an overview of those most commonly cited within academic literature, giving a brief explanation of the relative shortcomings in their usefulness in understanding low carbon controversies.

Based on insights from literature, we grouped these frameworks into:

- **linear**, which pertain to those that have been criticised for taking single problem-based explanations implying 'silver bullet' solutions;
- **factors influencing public attitudes**, which illustrate the complexity of public responses; and
- **multidimensional**, which pertain to frameworks that provide a more complex view of the reasons for public responses to low carbon technologies.

We give more attention to multidimensional frameworks which draw from a variety of research disciplines and methods, and thus offer a better understanding of the factors which influence the general public's opinions and responses to LCTs.

2.1. Linear perspectives

2.1.1. Knowledge deficit model

The **knowledge deficit** model of opposition to low carbon technologies proposes that public attitudes result from a lack of knowledge about the topic in question. This explanation of public opposition is one which has been common amongst many experts (Bauer et al., 2007) suggesting that if people, in particular host communities, were more informed, for example about the impacts of developments and the need for renewable electricity, then there would be less opposition. Similarly, Cass and Walker (2009) and Burningham et al. (2015) found that renewable energy developers and other actors believed that opponents spread misinformation about projects, and that people would become more positive about a particular project if they learnt more about the positive benefits from the technology and gained a better understanding of the impacts. The knowledge deficit model, however, has been criticised for providing a too simplistic view of public opposition (Owens, 2000), ignoring the social, psychological and institutional factors which influence attitudes and decisions about opposition and support (Owens and Driffill, 2008) and delegitimising the concerns and values of opponents (Bidwell, 2016).

More recently, Bidwell (2016) and others (e.g., Boamah, 2014; Sengers et al., 2010) have suggested that greater attention should be paid to how information shapes people's views of renewable energy, whilst acknowledging that this understanding may not lead to particular or desired outcomes. In a study where residents of coastal communities were invited to attend an information session about wind energy developments in general (rather than for a specific scheme), results of surveys with attendees suggested an increase in support for wind energy after the event, particularly amongst those who were less supportive prior to the information session (Bidwell, 2016). This study was, however, conducted with a small number of respondents (60 people attended events and 28 completed the survey). It was also conducted in a participatory setting where people not only received written information, but also had opportunities to discuss the topic with each other and ask questions. Creating opportunities for deliberation, as a means of supporting two way engagement which allows for the context-specific concerns of local people to be discussed, and potentially addressed, goes some way to alleviating many shortcomings of the knowledge deficit model. It is also worth noting that project information campaigns can backfire when the public does not trust those providing the information. The influence of consultation and deliberation processes in shaping publics' responses to LCTs are relevant to this discussion, and will be presented in Section 2.2.4, Contextual factors.

2.1.2. NIMBY or 'not in my backyard'

NIMBY or 'not in my backyard' is a term which has commonly been used by developers, policy-makers, the media and renewable energy supporters to describe those who may oppose a local project, despite claiming support for LCTs in general. It is also sometimes referred to as 'the individual gap' (Bell et al., 2005). The term NIMBY is generally used to imply that people selfishly protect their locality and put personal interests ahead of greater social good. The concept has long been critiqued by social scientists concerned that the NIMBY explanation is ill-defined (Van der Horst, 2007), over-simplistic and can mischaracterise reasons for opposition to a project (Abi-Ghanem and Haggett, 2011; Wolsink, 2006). Scholars also comment that it is a pejorative term which shuts down debate and undermines genuine and legitimate concerns, and that it is lacking a strong theoretical foundation (Devine-Wright, 2005; Wolsink, 2000) For example, visual impacts or impacts on wildlife may be given as a reason for opposition to wind turbines, however labelling these views as NIMBYism can hide the underlying concerns arising from strong place-based attachment rather than opposition to the turbines *per se* (Devine-Wright, 2009). NIMBY has been commonly been cited by politicians and developers as a barrier to renewable energy deployment, a framing within public policy that has been criticised with calls from amongst the academic community for it to be abandoned (Burningham et al., 2015; Devine-Wright, 2009; Wolsink, 2007, 2000). In a review of studies on wind energy, Bell et al. (2013) conclude that there is no evidence that there are people who hold the combinations of views associated with NIMBYism, and that self-interested free-riders who are not concerned about the impacts of wind energy on others are likely to be only a small proportion of the population.

In response to this debate, academics have proposed alternative frameworks for considering reasons for opposition and acceptance, recognising that members of the public have legitimate and multi-dimensional reasons for their opposition, acceptance and support for renewable energy and other low carbon technologies.

2.2. Factors influencing public attitudes

Devine-Wright (2007) draws on environmental psychological theory to propose that public attitudes to LCTs are shaped by factors at three levels: personal, social-psychological, and contextual. While, West et al. (2010) use cultural theory to explain that cultural and ideological identities also inform public perceptions on renewable energy. Table 3 provides a summary of the factors they identified, supplemented with additional factors that emerge from our review of recent research on LCT acceptance. It should be noted that there are some overlaps in the concepts discussed here; nonetheless, they all provide useful insights to understanding the processes that shape public attitudes towards LCTs.

Table 3. *Summary of factors influencing public attitudes towards LCTs*

Factors	Aspect	Source	Other aspects	Examples from recent literature
personal	age, gender, class, income	Devine-Wright (2007)		**bioenergy**, Maonga et al. (2015); von Maltitz et al., (2016) *CCS*, Ha-Duong et al., (2009) **transport**, Zhang et al. (2011)
social-psychological	knowledge and direct experience, environmental and political beliefs, place attachment	Devine-Wright (2007)	social ties and representation, emotional and moral concerns, communication and knowledge sharing behaviours	**bioenergy**, Sengers et al. (2010) CCS, Upham and Roberts (2011) **HVTL**, Nelson et al. (2018) **wave and tidal**, Devine-Wright (2011); Brownlee et al. (2015) **wind**, Sokoloski et al. (2018); Landeta-Manzano et al. (2018) **renewable energy (general)**, McLachlan and Mander (2012); Whitmarsh (2011)
cultural	responsibility, trust in government, trust in **others**, impact on local wildlife and ecosystem, interpretation of information, visual impact, impact on lifestyle	West et. al (2010)	shared local values, national narratives	**bioenergy**, Amigun et al. (2011); Vera-Castillo et al. (2014); Malone et al. (2018) **hydropower**, Díaz et al. (2017) **wind**, Klain et al. (2018) **wind and marine**, West et al. (2010)
contextual	technology type and scale, institutional structure, and spatial context	Devine-Wright (2007)	justice, fairnesss and trust; cost and benefits; process of deployment, consultation, and engagement	**CCS**, Wallquist et al. (2012b) **solar PV**, Diaz and van Vliet (2018) **transport**, Sweda and Klabjan (2011) **HVTLs**, Knudsen et al. (2015) **LCTs (general)**, Aitken et al. (2016); Roberts et al. (2012); Schweizer et al. (2016)

2.2.1. Personal factors

Public attitude surveys reveal sometimes conflicting and contrasting results for how awareness and opposition to LCTs vary with **socio-demographic characteristics** such as age, gender, class and income. In explaining personal factors, Devine-Wright (2007) cites studies which demonstrate greater support for renewable and nuclear generation amongst those on higher incomes and classified as upper and middle class, compared to working class, and those not in work.

Studies on alternative fuel and electric vehicle (EV) acceptance in China (Zhang et al., 2011) and fuel cell taxis in the UK (Mourato et al., 2004) also suggest that socio-demographic characteristics of vehicle drivers have influence on EV purchases. In Zhang et al.'s (2011) survey of 299 respondents from driving schools in Nanjing, they found that those who have high academic degrees and income are more willing to purchase EVs. While surveys with taxi drivers in London suggest that age is positively correlated with alternative fuel acceptance, where older respondents (potentially with higher income generating capacity) are more willing to pay a premium for using fuel cell taxis (Mourato et al., 2004).

In the same way, bioenergy research in the Global South attributes acceptance to the wealth of farmers. For example, results of studies on *Jatropha* cultivation in Malawi (Maonga et al., 2015) and Mozambique (Von Maltitz et al., 2016) show that locals who have more land are more likely to grow energy crops.

In terms of gender, a public perception survey on carbon capture and storage (CCS) with 1 076 respondents in France found strong correlation between gender and CCS acceptance, suggesting that women are more opposed to CCS because of concerns on risk and safety (Ha-Duong et al., 2009).

2.2.2. Social-psychological factors

Devine-Wright (2007) suggest that a person's degree of awareness and understanding about renewable and low carbon technologies, his or her political and environmental beliefs and concerns, place attachment and perceived fairness and level of trust in decision making have an impact on acceptance of LCTs. While these observations remain true and continue to be cited in academic literature, we also found that more studies now link these factors to peoples' moral and emotional concerns, and communication and knowledge sharing behaviours. Furthermore, explanations for public attitudes are also no longer only contextualised on the individual level (e.g., self-interest, compared to NIMBYism) but also in terms of social ties and relationships and how these shape peoples' opinions to LCTs.

Political beliefs
Political beliefs have been shown to have a positive correlation with acceptance (Devine-Wright, 2007) and on engagement with climate change generally (Hornsey et al., 2016). For example, Sokoloski et al. (2018) in their review of offshore wind energy projects in the US, suggest that US Democrats tend to support renewable energy, while Republicans support fossil fuel. Similarly, Hamilton et al.'s (2018) analysis of 2011-2017 national and regional surveys about public support for renewable energy in the US show that conservatives are more accepting of renewable energy than anthropogenic climate change. Those with right wing views are likely to be less concerned about climate change, and therefore more sceptical of messaging highlighting climate change as a concern (Whitmarsh, 2011). That said, research into framing narratives and messaging around 'conservative' values, e.g. reducing waste, suggests that reframing environmental narratives to resonate with peoples' values offers a way to engage people with climate change and environmental policies in ways which open up, rather than close down conversations (Whitmarsh and Corner, 2017).

Environmental beliefs
The relationship between environmental beliefs and acceptance of LCTs is recognised as being complex, with both supporters and opponents characterised by concern for environmental benefits and impacts. Devine-Wright (2007) suggest that supporters express concern for global environmental impacts arising from climate change, while opponents have concern over local environmental impacts.

However, more recent research shows some evidence that support and opposition can also vary depending on which environmental beliefs (and values) a person regards as more important. For example, weighing up concerns on environmental justice and rural development, Sengers et al. (2010) found that opponents of biofuels tend to be those who are concerned with impacts of land use change in the Global South, while supporters are those who see the benefits of bioenergy for environment and economic development in Europe. It should be noted however, that they argue that this could also be attributed to how messages on bioenergy have been crafted by the media, as will be discussed in the latter part of this section, '*communication and knowledge sharing behaviour*'.

Place attachment

Opposition and support for LCTs can also be attributed to place attachment, the emotional attachment that people feel for particular places (see for example Devine-Wright, 2007; McLachlan, 2009a, 2009b). Studies on offshore wind have used place attachment to explain opposition for LCTs in relation to anti-change narratives (i.e., marine areas' scenic views, use for recreation purposes versus building turbines) (e.g., Brownlee et al., 2015; Devine-Wright and Howes, 2010); while others have used it to explain how LCTs can also enhance emotional attachments to the place. Devine-Wright (2011) argues that the latter is possible for as long as symbolic meanings become associated to the LCT project. For example, results of the survey and follow-up focus group discussion conducted with residents in a Northern Ireland community suggest that participants agree that their place lacked vitality, was too quiet, and needed to liven up, and therefore, the tidal energy project added value to it (Devine-Wright, 2011). Stakeholder responses to marine energy have been shown to relate to how both the technology and place have been interpreted and what these symbolise. For this project, stakeholders who saw the technology as 'experimental' and the place as 'natural' objected to deployment in contrast to those who saw the technology as 'pioneering' and the place as a 'resource' who supported deployment (McLachlan, 2009a).

In Devine-Wright's succeeding papers explaining place attachment (Devine-Wright, 2011; Devine-Wright and Batel, 2017), he adds that notions of place-related symbolic meanings, social bonds, and forms of identity (including identities on energy beliefs and attitude) attached to the place (e.g., national and global), not only provide an alternative to the NIMBYism conceptualisation but also allow understanding of social acceptance of LCTs (See Section 2.3.3).

Emotional and moral concerns

In many studies of wind energy, aesthetics, sound and visual impact of projects continue to be concerns (Rand and Hoen, 2017) but recent research now makes a link between the physical impacts, and the emotional and moral concerns of local people. Landeta-Manzano et al. (2018) cite the importance of recognising community members' **emotional dependence** on place and explains that any alteration (visual, sound) can affect individual attitudes and behaviour. Klain et al. (2018), on the other hand, relates emotions-based affections to how wind turbines may also pose threat to wildlife in New Zealand. In Rand and Hoen's (2017) review of wind energy deployment in the US, however, they argue that while individuals have environmental concerns (e.g., wildlife, climate change) these do not matter to them as much as other factors (e.g., economic, landscape impact).

Social ties and representation

Research on the installation of high voltage transmission lines (HVTLs) by Nelson et al. (2018) suggests that residents who live close to a project and are more connected to each other are more likely to oppose it. They explain this through psychosocial perceptions of risk – that a person's attitude can be shaped by their social interactions and communication with other people. They further argue that these interactions form the basis of how residents perceive risks and develop trust with other people in the community and about processes related to technology deployment (p.572). This aligns to research on social norms arguing that individuals have more incentives to act as a group rather than alone (Nyborg et al., 2016). For CCS technologies, van Alphen et al. (2007) explain that the societal voice will be most important in the acceptance of CCS technologies, or when members of local communities have the opportunity to **voice** their concerns about the project.

Previous experience and degree of awareness and understanding

Incorrect perceptions about LCTs based on people's current knowledge and previous experience continue to be cited as reasons for public opposition. Some studies attribute this to the (un)availability of information and lack of clarity about the technologies (Sokoloski et al., 2018), while others suggest that it could be about the perceived complexity and lesser popularity of the particular technology compared to other LCTs, as in the case for CCS and EVs. It should also be noted that controversies surrounding low carbon energy technology siting are often teeming with competing technical information or 'knowledge claims', made both by opponents and proponents. Drawing on work focusing on biomass, CCS, onshore wind and wave energy, McLachlan and Mander (2012) highlight a number of key framing issues in relation to 'knowledge claims', namely: what are the most important issues, and how these should be measured or assessed; the acceptability of impacts and who assesses them; the value of local knowledge and real-world experience to question technical expertise; social assumptions related to monitoring and uncertainty over impacts. With these points in mind, it is therefore interesting that some perception studies about LCTs (Sweda and Klabjan, 2011; Wallquist et al., 2012a) continue to recommend raising awareness about the technologies. Critics, however, warn against relying on results of public perception studies as a 'substitute for reality' arguing that resistance to LCTs cannot be merely explained by understanding public perceptions (Sengers et al., 2010; Sokoloski et al., 2018).

Where the public has a level of awareness about LCT, as discussed by Soma and Haggett (2015) in relation to offshore wind farms in the UK, previous (negative) experience could also lead to objections to LCT development. Soma and Haggett (2015) report that local residents of areas where wind farms are typically developed (due to the availability of permits) perceive that their area has become overcrowded, and are concerned that the benefits of building new wind farms are minimal compared to costs (Soma and Haggett, 2015).

Alternatively, in fracking, Howell's (2018) survey results of 1 745 British adults indicate that the more people know about fracking, the more they oppose this technology. This has also been observed in a CCS public perception survey in France where high acceptance (58 %) for technology was noted before explaining adverse impacts (e.g., possibility of leakages that might impact human and animal health) of CCS to the respondents as part of the second part of the survey which has led to lower acceptance values (37 %) (Ha-Duong et al., 2009). Similarly, in focus groups conducted in five European nations by Upham and Roberts (2011) concerns about CCS which emerged were not allayed by the information which was provided to participants. These results and others (see for example Riesch et al., 2013) may also be linked to how messages were delivered, online or face-to-face for example, and crafted..

Communication and knowledge sharing behaviour

Many recent studies now highlight the relevance of how messages are framed about LCTs and their influence towards public acceptance or opposition; in particular for new and unfamiliar technologies (see for example Boyd and Paveglio, 2012) . In the Netherlands, results from Sengers et al.'s (2010) content analysis of newspaper articles suggest that information on biofuels provided by the media has shaped debates about the topic. They explain that the **interpretive cognitive framing of media** on techno-economic and regional claims (i.e., bioenergy as a technological and economic solution for renewable energy in Europe) versus socio-ecological and global claims (i.e., bioenergy as harmful to land use change in the Global South) has led the public to either support or resist bioenergy. Where the media portrays a more neutral view of a technology (see for example a study in CCS in the Netherlands by van Alphen et al. (2007) the limited information provided by the media (in this instance how CCS addresses climate change, uncertainties about its safety) does not allow lay people to make an assessment of the technology.

Given also the importance of trust, and that publics have different levels of trust in different actors, the impact of media reporting on perceptions will also be influenced by the extent to which the public considers contributors to be trustworthy and credible. Giordono et al. (2018)'s study on wind energy deployment in the US also report the possibility that opponents reframe messages related to risks posed by technology development (e.g., health and safety issues, decreasing property values). They further argue that this can also be shaped by existing processes of public participation, as will be discussed in the latter part of this section, contextual factors.

These observations indicate how other people's opinions can affect the public's perceptions of LCTs. They also prove how resistance or acceptance of LCTs might be shaped by strategic use of media.

2.2.3. Cultural factors

Using cultural theory as a framework to understand public responses, West et al. (2010) subscribed to the notion that individuals' worldviews (their cultural and ideological identities) and societal factors (people's embeddedness into groups, their influences and sources of information) can shape behaviour and opinion about LCTs.

Results of their focused group discussions with members of communities in South West England on the resource potential for wind and marine (e.g., tidal and wave) energy generation suggest several aspects which explain perceptions of renewable energy. These are: personal responsibility (e.g., concern for future generations); trust in government; trust in others (e.g., in other people, institutions); impacts on local wildlife and ecosystems; interpretations of information; visual impact (e.g., landscape feature such as turbines and viaducts as positive statement); and impact of renewable energy on lifestyles (e.g., environmental conscience, changing lifestyles) (West et al., 2010). Related to these, we also found similar explanations related to trust and responsibility aspects of culture: shared local values and national narratives (see for example Klain et al., 2018; Malone et al., 2017).

Shared local values
Klain et al.'s (2018) findings on wind energy acceptance in New Zealand also point to shared local values surrounding affective aspects towards wildlife. This resonates with studies of bioenergy deployment, particularly when locals perceive new technologies to threaten local values. For example, Amigun et al. (2011) found that farmers in Eastern Cape, South Africa perceive that growing bioenergy crops would change their community character. Similarly indigenous communities in Totonacapan, Mexico are not willing to exclusively grow *Jatropha* for commercial purposes as this is grown by locals for traditional uses (e.g., using seeds and leaves for medical purposes) (Vera Castillo et al., 2014).

National narratives
Evidence from the study of Malone et al. (2017) suggest that connecting renewable energy policies with governments' national narratives or to those pertaining to their cultural identities and values which the public believe as true, can help ensure acceptance and diffusion of large scale technologies. They studied the cases of Sweden for biofuels, Brazil for ethanol and USA for nuclear power and interviewed government officials, policy-makers, industry managers, researchers and analysts in each country. Their analysis suggest that governments' renewable energy policies had strong links to their national narratives and this ensured success (e.g., Sweden's biofuel linked to narratives on their love of nature, Brazil's auto-fuels linked to narratives of unity of different races and **hard-won** knowledge, and the USA's nuclear power linked to narratives of growth and new frontiers). However, they also cite that distrust in the central government can lead to failures of national narrative in eliciting support for LCT (e.g., for nuclear deployment in the USA, counter-narratives related to environmental destruction) (Malone et al., 2017). This perspective further suggests the potential role of governments in shaping opinions about LCTs.

Díaz et al. (2017), however, report that there may be differences in the values and priorities of different levels of government. Results of their interviews with 12 participants from nine hydropower stakeholder groups in Switzerland reveal that local and regional actors (e.g., local residents, cantonal representatives) prioritise increases in electricity production (e.g., large hydropower) without reducing consumption; while the national government prioritises energy efficiency and reduction of power consumption, along with addressing societal needs (e.g., wise use of natural resources, sustainable development). They suggest that this non-alignment in policy targets can potentially be solved through inclusive and equitable decision making processes among all stakeholders (See Section 3.2).

2.2.4. Contextual factors

In understanding what shapes publics' behaviour towards LCTs, it is also important to note that different technologies face different issues. According to Devine-Wright (2007), **contextual factors** such as technology type, scale of implementation (micro, meso, macro) and spatial context (regional, local) have different impacts and thus, may elicit different levels of institutional support and public attitudes. Within these factors, research now also looks into aspects of technology costs and benefits, justice, and processes of deployment to explain acceptance and opposition to LCTs.

Technology type and scale
Wallquist et al.'s (2012b) research on public acceptance of the elements of the CCS chain (capture, pipeline, and storage) revealed that Swiss residents are more open to the technology if CCS is combined with bioenergy.

Devine-Wright (2007) suggest that some types of LCTs may be more accepted at a smaller scale than at a larger scale. Many renewable energy technologies in the Global South, for example, are deployed at community level, evident in the proliferation of mini-, micro- and nano-scale projects (Cloke et al., 2017). It is relevant to note, however, that while a number of studies support the notion that small scale LCTs are valuable in delivering renewable energy (e.g., household biogas, in He et al., 2013), some also suggest that they do not always assure successful adoption (e.g., village-scale bioenergy projects in India, Bluemling and de Visser, 2013; biogas mini-grids in Uganda, Eder et al., 2015). Scholars (e.g., Campbell et al., 2016) suggest that this might be because of technocratic approaches to energy delivery and homogenous assumptions about communities, giving insight on other social and cultural factors which explain public responses towards LCTs.

Cost and benefits
Technology acceptance is commonly seen to be driven by potential socio-economic impacts. This was observed to be the case with wind energy projects in the US (Rand and Hoen, 2017) and in solar PV projects in Switzerland (Díaz and van Vliet, 2018) where public acceptance was attributed to LCT's potential contribution to the regional economy. Howell (2018), however, argues that promoting economic benefits is not enough to ensure support from the public.

In the case of electric vehicle adoption in the US, Sweda and Klabjan (2011) used an agent-based decision support system to identify purchase behaviours for residential EV ownership. Their results suggest that despite the perceived inconvenience (e.g., finding charging stations) in owning battery EVs, there tends to be more interest and higher EV purchases when gasoline prices increase (Sweda and Klabjan, 2011). Where publics have a **conditional** acceptance for LCT because of high financial costs, van Alphen (2007) suggest that technologies should be financially attractive so that it can encourage investments from industry.

There is also evidence from literature that potential community benefits (economic and also moral) arising from LCT projects (e.g., residents consider project an **exciting novelty** in Devine-Wright, 2011, tidal energy in Northern Ireland; energy provision in He et al., 2013, biogas in China) could encourage members to support, participate, and take ownership of the projects.

Justice, fairness, trust

Justice and perceptions of fairness and trust in siting and planning processes have been shown to affect public acceptance of renewable energy development. This can be understood in two ways: one, on how projects engage and provide equitable benefits to local stakeholders (See procedural justice, described in Section 3.2*)*; and two, whether or not locals trust project developers that offer LCT options despite perceive risks (e.g., **outsiders** bringing unfamiliar technology, uncertainties about the technology itself, projects that might focus on corporate profits instead of local benefits).

Rand and Hoen (2017) noted fairness and trust as important determinants of support in studies of wind energy in the US. In the Global South, the credibility of project developers, and hence the extent to which they are trusted by local people centres on potential benefits and risks arising from a project. For example, Amigun et al.'s (2011) study of biodiesel production in Eastern Cape, South Africa found that communities do not trust the biodiesel developers. Due to their past experience with corporations that introduced genetically modified organisms (GMOs), locals are concerned that the project will change their community character, or that they might be enslaved or be more poor because of it. Contrastingly, Eswarlal et al.'s (2014) study in India reports that locals were initially apprehensive of the rice husk bioenegy project until the developer (private company) found a way to compromise. Results of their in-depth interviews revealed that the developer earned the trust of the community by providing infrastructures such as temples, and irrigation facilities and various kind of support that their local schools needed.

In Nelson et al.'s (2018) study of opposition to high-voltage electricity transmission lines in the US, they found that if locals trust the project sponsor, they do not mind living near the project. While they also reported that neighbours who are more connected are likely to oppose *(*See *'social-psychological factors'),* their results also give an indication as to what extent social ties matter compared to their trust on the project sponsor. They conclude that trust 'moderates the relationship between distance to the project and opposition' (p.590) and highlight the importance of trust-building as related to LCT projects.

In their longitudinal study of wind farms in Spain, China, USA, India, Brazil and Mexico, Landeta-Manzano et al.'s (2018) interviewed equipment manufacturers and found that the safety of workers is crucial to community acceptance. This is the same argument made by qualified supporters (See Social Gap, Section 2.3.2) of CCS who were found to support the technology only if it is proven safe, and if it is deployed partially (i.e., matched with investments in renewable energy, as a **partial** solution to climate change) and temporarily (e.g., only for several decades) (van Alphen et al., 2007).

Process of deployment, consultation, and engagement

The need for open and transparent communication and engagement is a common theme running through much of the literature on social responses to low carbon technology and providing opportunities for public engagement in energy planning is identified as a key approach to engendering public support for low carbon energy deployment (see for example Aitken et al., 2016; Roberts et al., 2012; Schweizer et al., 2016). More importantly, research shows that beyond community consultation, more local groups want **to be taken seriously**, for example, by serving as facilitators in project development (Landeta-Manzano et al., 2018). Authors find value in public engagement to break the cycle of NIMBYism (Landeta-Manzano et al., 2018) and to overcome democratic and knowledge deficit (Sokoloski et al., 2018).

Crucially, given the importance placed on engagement within policy, engagement approaches themselves sometimes contribute to opposition to a renewable energy scheme (see for example Giordono et al., 2018; Roberts et al., 2012). The impact of certain aspects of consultation approaches or recommendations for how controversy and objections could have been reduced if consultation activities had been improved, is a recurrent theme in the literature on public perceptions of renewable energy (see for example Devine-Wright, 2005; Gross, 2007;Simcock, 2016; Upreti, 2004; Upreti and van der Horst, 2004).

There are three main rationales for public engagement in planning (Stirling, 2007): it can result in better decisions (substantive rational), it may be a means of engendering support for a particular decision (instrumental rational) or it may be regarded as the right thing to do from the point of view of democracy (normative rational). There are many different approaches to engagement ranging from informing people about a decision to taking decisions collectively. Rowe and Frewer (2005) consider the flows of information between participants to define different forms of engagement and identify: communication, consultation and participation. At its most basic, **communication** involves a one way flow of information between a 'sponsor' and the public; feedback is not sought or required, as a decision has already been made and there is little opportunity for people to express their views. Evidence from case studies, including wind energy planning in the UK (Aitken et al., 2016) and the planning of HVTLs in the UK and Norway (Knudsen et al., 2015) suggests that many engagement exercises are undertaken for regulatory reasons and not with the aim of involving host communities.

In the second type of engagement, **consultation**, information flows from the public to the sponsors of the consultation with the sponsors initiating the process Government policy consultations follow this format with responses invited to a set of questions focusing on a written policy document. Other mechanisms include public meetings, exhibitions and roadshows which can allow for a two way flow of information between project proponents and host communities (see for example Simcock, 2016). The framing of the consultation, the questions asked, the options presented, changes made in response to the consultation and the manner in which these are feedback are key elements to determining the success or otherwise of a consultation exercise.

The final type of engagement, **participation**, provides a mechanism for dialogue and a two way flow of information between sponsor and the public or their representatives. Deliberative processes such as citizen panels or public dialogues offer the potential for different knowledge and expertise to be brought to the table, positions to be altered and new outcomes to be negotiated. A collaborative approach to decision making which better takes the views of local people, stakeholders and communities into account may help to overcome issues of democratic deficit (See Section 2.3.2) (Bell et al., 2005). The challenge here however is in ensuring genuine and inclusive participatory decision making (see for example Howell, 2018; Schweizer et al., 2016; Simcock, 2016).

The importance of the process of engagement has already been highlighted where one of the rationales for the engagement is to increase the democracy of decisions and foster environmental citizenship. This leads us to consider what constitutes a good engagement process? Focusing on processes of engagement, Webler (1995) identifies two criteria essential for effective engagement: fairness and competence. Fairness is essential to ensure a process where everyone can participate on an equal footing and where participants have equal control over the process, in terms of shaping the agenda and choosing a facilitator, for example. Competence refers to the capacity within the process to provide participants with knowledge and explanations of terms as well as procedures to resolve disputes about knowledge and to ensure the authenticity of claims. In addition to a process that can be characterised by fairness and competence, trust between parties is vital for a successful participatory process (see for example Slovic, 2001; Webler et al., 1995). Trust between the various parties is important both in the facilitation of effective communication (Slovic, 1993) and also to generate confidence in the process outcome (Simcock, 2016).

Questions also arise as to who should develop and deploy low carbon energy technologies. Local ownership of wind projects is common in many European nations. The level of local ownership and deployment has arguably been a key factor in the level of deployment of wind farms in Denmark and Germany, for example. That said, whilst some studies suggest that community-led projects can lead to higher levels of local support (see for example Devine-Wright, 2005) a view which is prominent in political discourse surrounding community energy, other studies demonstrate that community projects can also encounter local opposition (Simcock, 2016; Walker, 2010).

2.3. Multidimensional perspectives

The frameworks presented here offer an alternative to linear perspectives (Section 2.1) in providing a deeper understanding of public responses to LCTs.

2.3.1. The VESPA framework

Similar to the classification of factors influencing opposition to wind turbines of Devine-Wright (2005; 2007), Petrova (2016) classifies the concerns of local populations over wind energy projects into the VESPA framework with four categories: visual/landscape, environmental, socioeconomic, and procedural. The review of published studies identifies visual impacts and impacts on noise as the most commonly cited reasons for opposition to wind energy projects. Environmental factors relate to impacts and benefits from the local to the global scale. The primary environmental benefits of wind energy are their contribution to mitigating climate change, and potential avoidance of climate impacts, through the generation of low carbon electricity whilst the environmental impacts are perceived to be local, arising from facility siting e.g., impacts on birds, bats and on local flora. Within the framework, socio-economic aspects relate to economic impacts and benefits of schemes. Local people may receive compensation or developers may support a fund for the local community and schemes may bring economic benefits to local communities, in the form of jobs, establishing local supply chains or tourism. Conversely, there may be concern about the impact of a local wind energy scheme upon house prices and the loss of local income from tourism if a scheme is perceived to detract from the attractiveness of a locality. Experiences of host communities in relation to how projects are sited and the associated planning processes have been shown to affect the acceptance or otherwise of a project. Important factors relate to elements of procedural justice (Simcock, 2016) and include open and transparent engagement, trust in project developers and a need for siting and decision making processes which are fair and transparent.

2.3.2. Social gap framework

Focusing specifically on onshore wind energy in the UK, Bell et al. (2005) highlight what they call a 'social gap', where the gap is between the high levels of support for wind energy which is expressed in public surveys, yet a low rate of success for wind energy schemes in the planning process. Three reasons are offered for the 'gap'. First, there is a **democratic deficit** whereby those making planning decisions may hold differing views about a particular technology than the wider population. For the case of wind energy as outlined in Bell et al. (2005), it is suggested that decision makers may hold views which are against wind energy, and which are unrepresentative of the wider population who support wind energy. The remaining two reasons relate to the people's attitudes. **Qualified supporters** express high levels of support for wind energy but support is conditional on schemes meeting certain characteristics. The third explanation, **self-interest**, has parallels with the NIMBY framing whereby opposition is for selfish reasons. This framework has been used in other UK-focused studies which support the **qualified support** explanation, for example, research by Jones and Eiser (2009) on onshore wind and Sturzaker (2011) on housing. Critique from Agterbosch et al. (2009) has been on the basis that the three explanations for the social gap are not mutually exclusive, and do not adequately take account of the complexity of the policy process and social context within which implementation takes place.

Sokoloski et al. (2018) distinguish between supporters and opponents of offshore wind in the US and argue that survey participants who identify themselves as supporter or opponent make incorrect assumptions about the level of support for the technology amongst other members of the community. By analysing survey results against cognitive framings of opinion estimation, they explain that supporters tend to be the silent majority or individuals who do not engage but assume that others do (pluralistic ignorance); while opponents are the vocal minority or those that incorrectly assume that they are the majority (false consensus). This can be linked to the **democratic deficit** explanation of the social gap which implies that the silent majority has to find their voice and begin to actively participate in developments of LCTs (McLachlan, 2009a; van Alphen et al., 2007).

In response to these critiques, Bell et al. (2013) have proposed three refinements to their typology to take better account of the range of public opinions on wind power, and power relations within local wind energy politics. Firstly, to the previously identified **qualified support** and **self-interest** they add a third attitude type, the **place protector** (Devine-Wright, 2011, 2009). **Place protectors** differ from qualified supporters and self-interested opponents in that their qualified support or opposition to wind energy is not for self-interested reasons, rather they oppose development because of the value and emotional attachment they place on a particular location whilst not seeing the same value in other places, where development could take place. Recognising this distinction in terms of these attitudes (e.g., place protector or qualified supporter*)* is important as people will respond differently to planning practices depending on these attitudes. Place protectors, for example may not respond as positively to financial incentives from developers as those with self-interested attitudes. Secondly, Bell et al. (2013) suggest that the conditions that qualified supporters require developments to meet should be made explicit, suggesting that a typology (e.g., one proposed by Devine-Wright, 2005) provides a transparent and systematic framework for understanding the dimensions of public concerns about wind energy. Thirdly, Bell et al. (2013) suggest that recognising the relationships between different concerns about wind energy schemes would enable a better understanding of how the scheme's design could address the concerns of different types of qualified supporters.

Bell et al. (2013) have focused on wind energy which, at present, is the renewable technology which is most often researched, because of a history of public opposition, however they caution that there may be a similar gap between public support for other renewable technologies, and successful deployment. This points to a need for policy-makers and developers to acknowledge and take account of the complexity and multidimensionality of public views on renewable and low carbon technologies.

2.3.3. Social acceptance

Wustenhagen et al. (2007) propose a three dimensional conceptualisation of acceptance to guide future research on renewable energy innovation; the three dimensions are socio-political, community and market acceptance. The socio-political dimension relates to the manner in which national policy objectives are translated into local projects, and the development and expansion of local, bottom-up initiatives. This dimension also covers the policy and incentive arrangements required to bring about rapid and effective expansion of renewable energy. Visual impact is judged to be the key source of objection in the context of deployment of wind energy, but key issues in relation to other emerging and less mature technologies will be different and remain to be identified. The market acceptance dimension relates to the process of market adoption of new technologies, where low carbon energy needs to be accepted by consumers and investors. This suggests that intermediaries in the deployment of micro-generation technologies, relationships between large energy firms and smaller renewable energy providers and the acceptance of renewable energy investments in the financial sector will all be important factors in the deployment of low carbon technologies. Each form of acceptance is not on its own enough to ensure successful deployment of low carbon technologies, rather there needs to be an alignment between political, community and market interests (Sovacool and Lakshmi Ratan, 2012). This framework is highly cited, yet Devine-Wright et al. (2017) make two observations. In the first instance, they conclude that most studies using it have only considered one of the dimensions in their analysis and secondly, that there is a lack of consideration of how the dimensions relate across geographical scales (from local to the international).

2.3.4. Social licence to operate

Originating in the 1990s mining industry (Dowd and James, 2014), a social licence to operate (SLO) can be broadly defined as the informal permission granted by a local community and broader society for the industries to undertake technical activities (Thomson and Boutilier, 2011), where approval is both initially gained and maintained for the long term (Dowd and James, 2014). The term is becoming widely used in sectors which are seen as controversial (Hall et al., 2015; Raman and Mohr, 2014) and where there are debates around environmental and social issues. The meaning and use of SLO differs across industries but all definitions of a social license encompass legitimacy, credibility and trust (Baumber, 2018; Dowd and James, 2014; Thomson and Boutilier, 2011). A social license goes beyond acceptance or support for a particular industry or technology, and instead should be viewed as a continuum, withheld at one end, passing through acceptance and being viewed positively, ideally reaching a point where an industry is supported and welcomed (Parsons and Moffat, 2014; Thomson and Boutilier, 2011). People's views, beliefs and opinions can also change over time, and particularly with experience of living with technology or installation, thus a social license should be seen as dynamic, and something that project proponents must work to maintain (Dowd and James, 2014; Edwards and Lacey, 2014).

The SLO concept has been usefully applied to explore social responses to the deployment of energy infrastructure including hydraulic fracturing in the US (Smith and Richards, 2015) and the UK (Bradshaw and Waite, 2017; Gough et al., 2018), large hydropower (Jijelava and Vanclay, 2018) and energy crops (Baumber, 2018; Edwards and Lacey, 2014). These studies demonstrate that where projects fail to gain a social license they can be opposed by local communities to the extent that projects have not proceeded, or proceed in the face of significant opposition and therefore costs to companies and local governments. This latter has been the case in Lancashire (UK), where longstanding public protest against shale gas extraction continues to incur considerable expense to companies and the public purse, along with negative publicity (Bradshaw and Waite, 2017). Where proponents fail to adequately demonstrate the legitimacy of proposals in social (Jijelava and Vanclay, 2018) or environmental terms (Bradshaw and Waite, 2017), lack credibility and or where there is a lack of trust between industries and local people (Baumber, 2018; Jijelava and Vanclay, 2018; Smith and Richards, 2015) a social license is not achieved. Gough et al. (2018) compared the SLO for CCS and hydraulic fracturing in the UK, concluding that the fracking industry has failed to establish a social license within local communities where industry activities are taking place, and with wider publics, despite national Government support. In contrast, the CCS industry is at an earlier stage of deployment with limited quantities of carbon dioxide (CO_2) stored to date, and industrial CCS has a particular strong foundation in communities where deployment is likely, and is well placed to establish an SLO as long as attention is given to maintaining positive and open relationships which are mindful of social contexts in which the technology is to be deployed. Once lost, a social license is hard to regain, as was the case in the town of Barendrecht in the Netherlands, where a lack of trust between local people and project proponents and a perceived lack of fairness within decision-making processes were shown to be instrumental in the opposition to proposed onshore storage of captured CO_2 in and the subsequent abandonment of the project (Terwel et al., 2012).

Critics of the social license framework argue that the concept is vague and hard to measure, which limits its usefulness (Owen and Kemp, 2013) both as a research approach, but also in practice as it lacks legal standing (Bradshaw and Waite, 2017) and is defined different by different stakeholders

(Moffat et al., 2016). It is also argued that companies are likely to know when they do not have a social license thus the approach has emerged in response to opposition, rather than in a genuine attempt by companies to engage more fully with issues of environmental and social responsibility (Owen and Kemp, 2013). That said, even those critiquing the social license concept accept that the approach allows project proponents to gain a more multi-dimensional and holistic understanding of the social responses to a particular development (Owen and Kemp, 2013) whilst providing a basis to inform local communities in their interactions with project proponents and other stakeholders (Bradshaw and Waite, 2017).

Diverse low carbon technologies, each with their own characteristics, impacts and benefits, are deployed at different spatial scales and contexts; each technology implies different roles and has differing implications for people. For grid connected renewable generators, e.g. wind and or large-scale solar, a community is the host for the technology, and planning permission will be required with engagement with local people as part of this process. At this scale and in a particular local and national context, those looking to deploy the technology can learn a lot from best practice for other types of development; open and transparent engagement which builds trust with local people and other stakeholders is key to achieving a SLO. At this scale, legitimacy relates to whether project proponents have established the need for the project – how does it fit into broader ambitions and targets for energy policy for example? What are the alternatives to this particular technology or location, and how have people been informed and engaged with? It is important to note here that awareness of individual technologies may be low so opinions may not have been formed. Host communities will judge the credibility of a technology provider according to their judgement of the level of technical competence, understanding of local context, and people's views of a company.

That said, individual technologies also need to be judged within the context of the wider low carbon transition, and the wide-spread transformation that needs to occur (Demski et al., 2015). The SLO is thus, something which will need to be secured in a specific spatial context, and within the context of this wider transition. Importantly, if a social license is lost and if a planning application becomes adversarial or polarised as a consequence, it is hard to turn this position around, which may have a negative impact on wider deployment (Gough et al., 2018)

Other technologies (e.g. electric vehicles, domestic PV or storage) require householders to invest in a technology and require a change in their domestic practice or behaviour. In this instance, technologies may again be unfamiliar and people will have concerns which need to be addressed. The manner in which such concerns are addressed and responded to will shape the credibility of those looking to deploy storage in homes (whether technology companies or housing providers, for example). In this context, establishing the legitimacy of the technology solution in a given context requires attention to questions such as the financial costs and benefits of having storage, and the legal and regulatory protections for users or owners. Moreover, PV, electric vehicles and storage require that people participate in energy markets in new ways as 'prosumers' or sellers of energy. Thus, how the market rules and their regulation are designed will shape user engagement, as will levels of trust in new market actors, or existing companies who may already be seen in a negative light and need to overcome this if they want to move into new market.

3. Proposed solutions

Two key solutions can be identified within the literature on public responses to LCTs which, if implemented could support the deployment of LCTs. The first solution is the integration of social and values-based aspects within energy planning at all scales from the local to the international. The second solution is to ensure procedural justice in the planning and deployment of low carbon technologies.

3.1. Integrating social and values-based aspects in planning

Demski et al. (2015) highlight that supply technologies cannot be considered in isolation of the interdependent system of supply and demand and moreover, that there is a need to consider people's underlying concerns and values. Low carbon transitions will require new technologies at different geographical and temporal scales; these will be unfamiliar to people and uncertain in terms of impacts and benefits. In these cases, views about a technology formed through a process of evaluating information (about technology, impacts, benefits and regulation) in the context of existing values, experiences and understandings. An understanding of people's values and concerns which underpin their assessment of a new technology can make for improved engagement and for better anticipation of where conflict may arise. Values are interconnected, not discrete, thus specific views about elements of the energy system will be informed by multiple values. Publics also place importance on overall changes in terms of a long term pathway rather than short-term solutions. Thus, for individual technologies or applications it is important to place these in the context of longer-term and wider changes. To be perceived favourably, changes also have to fit well with the overall value system within the society.

Key to integrating social and values-based aspects in planning for low carbon transitions is to understand underlying factors that influence public opinions. Literature suggests that this includes potential psychological, social, cultural factors that influence how the public's opinions are formed, their sharing behaviours (e.g., related to communication, interaction, and relationships with other members of community) and the potential emotional or affective dimensions of projects (e.g., sympathy for natural wildlife in the case of wind energy) (Klain et al., 2018; Sokoloski et al., 2018). Understanding these factors would aid understanding of the nature of public support or opposition. Others also suggest the importance of identifying potential (social) impacts of projects in communities where the LCT will be deployed and planning around it (Landeta-Manzano et al., 2018).

3.2. Ensuring procedural justice

Procedural justice refers to involving the people and communities that may be affected by deployment of LCTs in fair and equitable decision-making processes (Ottinger et al., 2014; Schlosberg, 2009). It is understood from literature that procedural justice can have a big impact on outcome of LCT deployment – especially in ensuring collaboration and genuine engagement from all actors.

Ottinger et al. (2014) suggest three criteria for meeting this: accessibility (e.g., locals are able to attend meetings after work hours), recognition of legitimacy (e.g., respect for inputs of participants), and addressing power inequalities. In addition to these criteria, we highlight a number of issues that could aid recognition of legitimacy and addressing of power inequalities in order to ensure procedural justice.

First, approaches to public engagement in LCT projects should take into account that locals may not only want to be consulted but also become active participants shaping the projects in a variety of ways (e.g., Landeta-Manzano et al., 2018). Current community involvement strategies in wind farm projects, for example, tend to consider locals as recipients (Landeta-Manzano et al., 2018). They also tend to overlook individual's practices and relationships (Batel, 2018).

Within the context of renewable energy in the Global South, Cloke et al. (2017) propose a Social Energy Systems (SES) approach that could be useful in improving public engagement strategies. This approach draws from socio-technical transitions and stresses co-production of technology and society and facilitating mutual transformations through education or literacy in community-based renewable energy projects. Instead of informing or consulting the host communities, SES incorporates energy literacy in renewable energy projects in three areas: (1) energy systems, so locals know the type of energy they will receive; (2) project community, for the developers to fully understand where the project will be deployed; and (3) political, for funders and implementers to know the implications of the energy transition, what tensions may arise and who might benefit. This is important since different stakeholders could have vested interests and might **fill in the holes** (or address knowledge deficit) based on assumptions (Sokoloski et al., 2018).

Second, approaches to addressing opposition should not be limited to overcoming opposition – for example, by compensating for risks (Howell, 2018) or increasing knowledge. According to Rand and Hoen (2017), viewing opposition as something to be overcome may prevent meaningful understanding and implementation of **best** practices. Furthermore, framing arguments around public opposition presumes that there is something wrong with the **public**, instead of also looking at what has not been done (correctly) by the government, technology developer or project implementers.

A potential opportunity could be taking a collaborative governance approach in LCT projects (Ottinger et al., 2014; Sovacool, 2012). This could allow different stakeholders to take roles, organise, and decide how they might want to address issues that arise. Ottinger et al. (2014) explain that collaborative governance allows for structures (e.g., working groups or local committees) that could facilitate deliberations, management of power dynamics and foster exchange of information without privileging powerful participants. Renewable energy projects that organise collective leadership such as this have also been regarded to be successful (Sovacool, 2012).

3.3. Integrating social and values-based aspects and procedural justice

Taken together, these solutions not only offer a way to understand (and find ways to address some of) the complexities behind public responses, they also set a platform for encouraging engagement from all stakeholders.

By integrating social and values-based aspects in planning and ensuring procedural justice throughout deployment, it is possible to achieve a social licence. This social licence, we argue, should be the overall ambition across society for a low carbon transition. As discussed earlier, since SLO elicits legitimacy, credibility and trust among stakeholders, this approach offers the potential for LCTs become accepted, deployed and maintained in ways that allow genuine and ongoing participation from the public in the low carbon transition essential to meet the urgent demands of climate change mitigation.

4. Policy options

On the basis of the understanding of public responses to renewable and low carbon technologies presented in this report, we outline four options for actions that could be embedded within policies for supporting a more effective transition to a low carbon economy by strengthening public engagement at all stages of the policy process, at all scales: (1) to engage publics in ways that support deliberative and participative planning approaches; (2) to understand that outcomes of public engagement may change technology types, scale and other aspects of deployment; (3) to recognise the value of trust that publics place with project implementers and how this might impact support for low carbon technology adoption; and (4) to respond to public concerns in ways that seek to engender support rather than seeking to overcome opposition. Each option requires thinking about how people interact with, interpret, use and make sense of low carbon technologies, and are further explored in the following sections.

4.1. Participatory public engagement within all aspects of energy planning

Frequently, public involvement in energy planning is limited to consultation related to the implementation of specific technologies, rather than encouraging participation in every aspect of energy planning, for example through the development of regional energy strategies or developing national visions of long-term transitions. This approach potentially risks locking in points of contention and misses opportunities to develop strategies which enlist local knowledge, and align with peoples' values and beliefs. As presented in this report, public participation should not be confined to communicating information, awareness-raising, and consultation. Instead, host communities can take active roles from project conception to siting and management.

4.2. Impacts and benefits of projects should be assessed using context-based measures

Public engagement may change projects in terms of technology type, scale, and other aspects of deployment. Thus, it must be accepted that there are different ways of assessing and evaluating impacts of LCT and their acceptability, and that there must be transparency and openness in relation to the terms of reference for any engagement process. For a given technology in a specific location, project proponents must understand the social context in which their scheme is situated. Moreover, it must be acknowledged that different questions are being asked by, and important to, different actors.

4.3. Create partnerships with locals and host communities

Policy actors must recognise the value of the trust that publics place with project implementers and how this might impact support for low carbon technology adoption. In the context of risks and safety or previous experience of poor performance and deceit, this further emphasises the importance of ongoing monitoring of projects and implementing mechanisms for liaison with local communities and to address concerns arising from deployment. Policies must ensure that frameworks are in place which support the creation of partnerships with locals and host communities, which turn place value in trust-building activities.

4.4. Provide guidance on designing effective processes which ensure fairness and build trust

Seeking to understand social responses to LCTs solely to overcome or avoid opposition is unlikely to build trust between project proponents, policy actors and local communities and stakeholders. Instead an understanding is required about how people interact with, interpret, use and make sense of low carbon technologies. Approaches to engagement should support deliberative and participative planning, allowing space for discussion and debate rather than close it down. Policies should include guidance on designing effective processes and which are fair and build trust, and for these to be evaluated to ensure their quality.

REFERENCES

Abi-Ghanem, D., Haggett, C., 2011. Shaping people's engagement with microgeneration technology: The case of solar photovoltaics in UK homes. Renew. Energy Public NIMBY Particip 149.

Agterbosch, S., Meertens, R.M., Vermeulen, W.J. V, 2009. The relative importance of social and institutional conditions in the planning of wind power projects. Renew. Sustain. Energy Rev. 13, 393–405. https://doi.org/https://doi.org/10.1016/j.rser.2007.10.010

Aitken, M., Haggett, C., Rudolph, D., 2016. Practices and rationales of community engagement with wind farms: awareness raising, consultation, empowerment. Plan. Theory Pract. 17, 557–576.

Alves Dias, P., Kanellopoulos, K., Medarac, H., Kapetaki, Z., Miranda-Barbosa, E., Shortall, R., Czako, V., Telsnig, T., Vazquez-Hernandez, C., Lacal Arántegui, R., Nijs, W., Gonzalez Aparicio, I., Trombetti, M., Mandras, G., Peteves, E., Tzimas, E., 2018. EU coal regions opportunities and challenges ahead. Publications Office of the European Union, Luxemborg.

Amigun, B., Musango, J.K., Brent, A.C., 2011. Community perspectives on the introduction of biodiesel production in the Eastern Cape Province of South Africa. Energy 36, 2502–2508.

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. J. Environ. Policy Plan. 20, 356–369. https://doi.org/10.1080/1523908X.2017.1417120

Batel, S., Devine-Wright, P., 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

Bauer, M.W., Allum, N., Miller, S., 2007. What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public Underst. Sci. 16, 79–95. https://doi.org/10.1177/0963662506071287

Baumber, A., 2018. Energy cropping and social licence: What's trust got to do with it? Biomass and Bioenergy 108, 25–34.

Bell, D., Gray, T., Haggett, C., 2005. The 'social gap'in wind farm siting decisions: explanations and policy responses. Env. Polit. 14, 460–477.

Bell, D., Gray, T., Haggett, C., Swaffield, J., 2013. Re-visiting the 'social gap': public opinion and relations of power in the local politics of wind energy. Env. Polit. 22, 115–135.

Bidwell, D., 2016. The Effects of Information on Public Attitudes Toward Renewable Energy. Environ. Behav. 48, 743–768. https://doi.org/10.1177/0013916514554696

Bluemling, B., de Visser, I., 2013. Overcoming the 'club dilemma' of village-scale bioenergy projects—The case of India. Energy Policy 63, 18–25. https://doi.org/10.1016/J.ENPOL.2013.08.032

Boamah, F., 2014. Imageries of the contested concepts 'land grabbing' and 'land transactions': Implications for biofuels investments in Ghana. Geoforum 54, 324–334. https://doi.org/10.1016/J.GEOFORUM.2013.10.009

Boyd, A.D., Paveglio, T.B., 2012. Front page or 'buried' beneath the fold? Media coverage of carbon capture and storage. Public Underst. Sci. 23, 411–427. https://doi.org/10.1177/0963662512450990

Bradshaw, M., Waite, C., 2017. Learning from Lancashire: Exploring the contours of the shale gas conflict in England. Glob. Environ. Chang. https://doi.org/10.1016/j.gloenvcha.2017.08.005

Brownlee, M.T.J., Hallo, J.C., Jodice, L.W., Moore, D.D., Powell, R.B., Wright, B.A., 2015. Place attachment and marine recreationists' attitudes toward offshore wind energy development. J. Leis. Res. 47, 263–284.

Burningham, K., Barnett, J., Walker, G., 2015. An Array of Deficits: Unpacking NIMBY Discourses in Wind Energy Developers' Conceptualizations of Their Local Opponents. Soc. Nat. Resour. 28, 246–260. https://doi.org/10.1080/08941920.2014.933923

Campbell, B., Cloke, J., Brown, E., 2016. Communities of energy. Econ. Anthropol. 3, 133–144. https://doi.org/10.1002/sea2.12050

Cass, N., Walker, G., 2009. Emotion and rationality: The characterisation and evaluation of opposition to renewable energy projects. Emot. Sp. Soc. 2, 62–69. https://doi.org/10.1016/j.emospa.2009.05.006

Cloke, J., Mohr, A., Brown, E., 2017. Imagining renewable energy: Towards a Social Energy Systems approach to community renewable energy projects in the Global South. Energy Res. Soc. Sci. 31, 263–272. https://doi.org/10.1016/J.ERSS.2017.06.023

Demski, C., Butler, C., Parkhill, K.A., Spence, A., Pidgeon, N.F., 2015. Public values for energy system change.

Glob. Environ. Chang. 34, 59–69. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2015.06.014

Devine-Wright, P., 2011. Place attachment and public acceptance of renewable energy: A tidal energy case study. J. Environ. Psychol. 31, 336–343. https://doi.org/10.1016/j.jenvp.2011.07.001

Devine-Wright, P., 2009. Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. J. Community Appl. Soc. Psychol. 19, 426–441. https://doi.org/10.1002/casp.1004

Devine-Wright, P., 2007. Reconsidering public attitudes and public acceptance of renewable energy technologies : a critical review. Sch. Environ. Dev. Univ. Manchester, Oxford Road, Manchester M13 9PL, UK 1.4, 14–48. https://doi.org/10.1046/j.1442-9993.2003.01294.x

Devine-Wright, P., Batel, S., 2017. My neighbourhood, my country or my planet? The influence of multiple place attachments and climate change concern on social acceptance of energy infrastructure. Glob. Environ. Chang. 47, 110–120. https://doi.org/10.1016/j.gloenvcha.2017.08.003

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

Devine-Wright, P., Howes, Y., 2010. Disruption to place attachment and the protection of restorative environments: A wind energy case study. J. Environ. Psychol. 30, 271–280. https://doi.org/10.1016/j.jenvp.2010.01.008

Devine-Wright, P., 2005.Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. Wind Energy An Int. J. Prog. Appl. Wind Power Convers. Technol. 8, 125–139.

Díaz, P., Adler, C., Patt, A., 2017. Do stakeholders' perspectives on renewable energy infrastructure pose a risk to energy policy implementation? A case of a hydropower plant in Switzerland. Energy Policy 108, 21–28. https://doi.org/10.1016/j.enpol.2017.05.033

Díaz, P., van Vliet, O., 2018. Drivers and risks for renewable energy developments in mountain regions: A case of a pilot photovoltaic project in the Swiss Alps. Energy. Sustain. Soc. 8. https://doi.org/10.1186/s13705-018-0168-x

Dowd, A.-M., James, M., 2014. A social licence for carbon dioxide capture and storage: how engineers and managers describe community relations. Soc. Epistemol. 28, 364–384.

Eder, J.M., Mutsaerts, C.F., Sriwannawit, P., 2015. Mini-grids and renewable energy in rural Africa: How diffusion theory explains adoption of electricity in Uganda. Energy Res. Soc. Sci. 5, 45–54. https://doi.org/10.1016/J.ERSS.2014.12.014

Edwards, P., Lacey, J., 2014. Can't Climb the Trees Anymore: Social Licence to Operate, Bioenergy and Whole Stump Removal in Sweden. Soc. Epistemol. https://doi.org/10.1080/02691728.2014.922637

ESS, 2018. European Attitudes to Climate Change and Energy. ESS Topline Results Ser. Round 8, 20.

Eswarlal, V.K., Vasudevan, G., Dey, P.K., Vasudevan, P., 2014. Role of community acceptance in sustainable bioenergy projects in India. Energy Policy 73, 333–343. https://doi.org/http://dx.doi.org/10.1016/j.enpol.2014.04.019

European Commission, 2018. EU energy in figures, Statistical pocketbook. Luxemborg.

European Commission, 2015. Intended Nationally Determined Contribution of the EU and its Member States. Riga.

European Commission, 2014. A policy framework for climate and energy in the period from 2020 to 2030. OPOCE. https://doi.org/COM/2014/015

European Environment Agency, 2018. Renewable Energy in Europe 2018. Luxemborg.

European Environment Agency, 2017. Renewable Energy in Europe 2017. Copenhagen. https://doi.org/10.2800/313983

EuroStat, 2016. SHARES (Renewables) [WWW Document]. Dataset. URL https://ec.europa.eu/eurostat/web/energy/data/shares (accessed 1.7.19).

German, L., Schoneveld, G., 2012. A review of social sustainability considerations among EU-approved voluntary schemes for biofuels, with implications for rural livelihoods. Energy Policy 51, 765–778. https://doi.org/10.1016/J.ENPOL.2012.09.022

Giordono, L.S., Boudet, H.S., Karmazina, A., Taylor, C.L., Steel, B.S., 2018. Opposition 'overblown'? Community response to wind energy siting in the Western United States. Energy Res. Soc. Sci. 43, 119–131. https://doi.org/10.1016/j.erss.2018.05.016

Gough, C., Cunningham, R., Mander, S., 2018. Understanding key elements in establishing a social license for CCS: An empirical approach. Int. J. Greenh. Gas Control 68, 16–25.

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, 2727–2736.

Ha-Duong, M., Nadaï, A., Campos, A.S., 2009. A survey on the public perception of CCS in France. Int. J. Greenh. Gas Control 3, 633–640. https://doi.org/https://doi.org/10.1016/j.ijggc.2009.05.003

Hall, N., Lacey, J., Carr-Cornish, S., Dowd, A.-M., 2015. Social licence to operate: understanding how a concept has been translated into practice in energy industries. J. Clean. Prod. 86, 301–310.

Hamilton, L.C., Bell, E., Hartter, J., Salerno, J.D., 2018. A change in the wind? US public views on renewable energy and climate compared. Energy. Sustain. Soc. 8. https://doi.org/10.1186/s13705-018-0152-5

He, G., Bluemling, B., Mol, A.P.J., Zhang, L., Lu, Y., 2013. Comparing centralized and decentralized bio-energy systems in rural China. Energy Policy 63, 34–43. https://doi.org/http://dx.doi.org/10.1016/j.enpol.2013.06.019

Hornsey, M.J., Harris, E.A., Bain, P.G., Fielding, K.S., 2016. Meta-analyses of the determinants and outcomes of belief in climate change. Nat. Clim. Chang. https://doi.org/10.1038/nclimate2943

Howell, R.A., 2018. UK public beliefs about fracking and effects of knowledge on beliefs and support: A problem for shale gas policy. Energy Policy 113, 721–730. https://doi.org/10.1016/j.enpol.2017.11.061

IPCC, 2018. Summary for Policymakers, 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,. Geneva.

Jijelava, D., Vanclay, F., 2018. How a large project was halted by the lack of a social Licence to operate: Testing the applicability of the Thomson and Boutilier model. Environ. Impact Assess. Rev. https://doi.org/10.1016/j.eiar.2018.07.001

Jones, C.R., Eiser, J.R., 2009. Identifying predictors of attitudes towards local onshore wind development with reference to an English case study. Energy Policy 37, 4604–4614. https://doi.org/10.1016/j.enpol.2009.06.015

Klain, S.C., Satterfield, T., Sinner, J., Ellis, J.I., Chan, K.M.A., 2018. Bird Killer, Industrial Intruder or Clean Energy? Perceiving Risks to Ecosystem Services Due to an Offshore Wind Farm. Ecol. Econ. 143, 111–129. https://doi.org/10.1016/j.ecolecon.2017.06.030

Knudsen, J.K., Wold, L.C., Aas, Ø., Haug, J.J.K., Batel, S., Devine-Wright, P., Qvenild, M., Jacobsen, G.B., 2015. Local perceptions of opportunities for engagement and procedural justice in electricity transmission grid projects in Norway and the UK. Land use policy 48, 299–308.

Landeta-Manzano, B., Arana-Landín, G., Calvo, P.M., Heras-Saizarbitoria, I., 2018. Wind energy and local communities: A manufacturer's efforts to gain acceptance. Energy Policy 121, 314–324. https://doi.org/10.1016/j.enpol.2018.05.034

Malone, E., Hultman, N.E., Anderson, K.L., Romeiro, V., 2017. Stories about ourselves: How national narratives influence the diffusion of large-scale energy technologies. Energy Res. Soc. Sci. 31, 70–76. https://doi.org/10.1016/J.ERSS.2017.05.035

Maonga, B.B., Maganga, A.M., Kankwamba, H., 2015. Smallholder Farmers ' Willingness To Incorporate Biofuel Crops Into Cropping Systems in Malawi. Int. J. Food Agric. Econ. 3, 87–100.

McLachlan, C., 2009a. 'You don't do a chemistry experiment in your best china': Symbolic interpretations of place and technology in a wave energy case. Energy Policy. https://doi.org/10.1016/j.enpol.2009.07.057

McLachlan, C., 2009b. Technologies in place: Symbolic interpretations of renewable energy. Sociol. Rev. 57, 181–199. https://doi.org/10.1111/j.1467-954X.2010.01892.x

Mclachlan, C., Mander, S., 2012. What have facts got to do with it anyway? Competing knowledge claims in low-carbon energy controversy, in: Low-Carbon Energy Controversies. Routledge, pp. 97–125. https://doi.org/10.4324/9780203105153-13

Moffat, K., Lacey, J., Zhang, A., Leipold, S., 2016. The social licence to operate: a critical review. For. An Int. J. For. Res. 89, 477–488.

Mourato, S., Saynor, B., Hart, D., 2004. Greening London's black cabs: a study of driver's preferences for fuel cell taxis. Energy Policy 32, 685–695. https://doi.org/https://doi.org/10.1016/S0301-4215(02)00335-X

Nelson, H.T., Swanson, B., Cain, N.L., 2018. Close and Connected: The Effects of Proximity and Social Ties on Citizen Opposition to Electricity Transmission Lines. Environ. Behav. 50, 567–596. https://doi.org/10.1177/0013916517708598

Nyborg, K., Anderies, J.M., Dannenberg, A., Lindahl, T., Schill, C., Schlüter, M., Adger, W.N., Arrow, K.J., Barrett, S., Carpenter, S., Chapin, F.S., Crépin, A.-S., Daily, G., Ehrlich, P., Folke, C., Jager, W., Kautsky, N., Levin, S.A., Madsen, O.J., Polasky, S., Scheffer, M., Walker, B., Weber, E.U., Wilen, J., Xepapadeas, A., de Zeeuw, A., 2016. Social norms as solutions. Science (80-.). 354, 42–43. https://doi.org/10.1126/science.aaf8317

Ottinger, G., Hargrave, T.J., Hopson, E., 2014. Procedural justice in wind facility siting: Recommendations for state-led siting processes. Energy Policy 65. https://doi.org/10.1016/j.enpol.2013.09.066

Owen, J.R., Kemp, D., 2013. Social licence and mining: A critical perspective. Resour. Policy. https://doi.org/10.1016/j.resourpol.2012.06.016

Owens, S., 2000. 'Engaging the Public': Information and Deliberation in Environmental Policy. Environ. Plan. A Econ. Sp. 32, 1141–1148. https://doi.org/10.1068/a3330

Owens, S., Driffill, L., 2008. How to change attitudes and behaviours in the context of energy. Energy Policy 36, 4412–4418. https://doi.org/https://doi.org/10.1016/j.enpol.2008.09.031

Parsons, R., Moffat, K., 2014. Constructing the meaning of social licence. Soc. Epistemol. 28, 340–363.

Peters, G.P., Andrew, R.M., Canadell, J.G., Fuss, S., Jackson, R.B., Korsbakken, J.I., Le Quéré, C., Nakicenovic, N., 2017. Key indicators to track current progress and future ambition of the Paris Agreement. Nat. Clim. Chang. 7, 118–122. https://doi.org/10.1038/nclimate3202

Petrova, M.A., 2016. From NIMBY to acceptance: Toward a novel framework — VESPA — For organizing and interpreting community concerns. Renew. Energy 86, 1280–1294. https://doi.org/10.1016/J.RENENE.2015.09.047

Raman, S., Mohr, A., 2014. A social licence for science: capturing the public or co-constructing research? Soc. Epistemol. 28, 258–276.

Rand, J., Hoen, B., 2017. Thirty years of North American wind energy acceptance research: What have we learned? Energy Res. Soc. Sci. 29, 135–148. https://doi.org/10.1016/j.erss.2017.05.019

Riesch, H., Oltra, C., Lis, A., Upham, P., Pol, M., 2013. Internet-based public debate of CCS: Lessons from online focus groups in Poland and Spain. Energy Policy. https://doi.org/10.1016/j.enpol.2013.01.029

Roberts, T., Upham, P., Mander, S., McLachlan, C., Boucher, P., Gough, C., Ghanem, D.A., 2012. Low-carbon energy controversies, Low-carbon energy controversies. Routledge, Taylor & Francis, London.

Rowe, G., Frewer, L.J., 2005. A typology of public engagement mechanisms. Sci. Technol. Hum. Values 30, 251–290.

Schlosberg, D., 2009. Defining environmental justice: Theories, movements, and nature. Oxford University Press.

Schweizer, P.-J., Renn, O., Köck, W., Bovet, J., Benighaus, C., Scheel, O., Schröter, R., 2016. Public participation for infrastructure planning in the context of the German 'Energiewende.' Util. Policy 43, 206–209.

Sengers, F., Raven, R.P.J.M., Van Venrooij, A., 2010. From riches to rags: Biofuels, media discourses, and resistance to sustainable energy technologies. Energy Policy 38, 5013–5027. https://doi.org/10.1016/J.ENPOL.2010.04.030

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.

Slovic, P., 2001. The risk game. J. Hazard. Mater. 86, 17–24.

Slovic, P., 1993. Perceived risk, trust, and democracy. Risk Anal. 13, 675–682.

Smith, D.C., Richards, J.M., 2015. Social license to operate: Hydraulic fracturing-related challenges facing the oil and gas industry. Oil Gas, Nat. Resour. Energy J. 1, 81–163.

Sokoloski, R., Markowitz, E.M., Bidwell, D., 2018. Public estimates of support for offshore wind energy: False consensus, pluralistic ignorance, and partisan effects. Energy Policy 112, 45–55. https://doi.org/10.1016/j.enpol.2017.10.005

Soma, K., Haggett, C., 2015. Enhancing social acceptance in marine governance in Europe. Ocean Coast. Manag. 117, 61–69. https://doi.org/10.1016/j.ocecoaman.2015.11.001

Sovacool, B.K., 2012. Design principles for renewable energy programs in developing countries. Energy Environ. Sci. 5, 9157–9162. https://doi.org/10.1039/C2EE22468B

Sovacool, B.K., Lakshmi Ratan, P., 2012. Conceptualizing the acceptance of wind and solar electricity. Renew. Sustain. Energy Rev. 16, 5268–5279. https://doi.org/https://doi.org/10.1016/j.rser.2012.04.048

Stirling, A., 2007. 'Opening Up' and 'Closing Down': Power, Participation, and Pluralism in the Social Appraisal of Technology. Sci. Technol. Hum. Values 33, 262–294. https://doi.org/10.1177/0162243907311265

Sturzaker, J., 2011. Can community empowerment reduce opposition to housing? Evidence from rural England. Plan. Pract. Res. 26, 555–570.

Sweda, T., Klabjan, D., 2011. An agent-based decision support system for electric vehicle charging infrastructure deployment, in: 2011 IEEE Vehicle Power and Propulsion Conference. pp. 1–5. https://doi.org/10.1109/VPPC.2011.6043201

Terwel, B.W., ter Mors, E., Daamen, D.D.L., 2012. It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. Int. J. Greenh. Gas Control 9, 41–51.

Thomson, I., Boutilier, R., 2011. Modelling and Measuring the Social License to Operate: Fruits of a Dialogue Between Theory and Practice, Social Licence to Operate …. https://doi.org/10.4000/vertigo.15139

UNFCCC, 2015. Decision 1/CP.21.

Upham, P., Roberts, T., 2011. Public perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications. Int. J. Greenh. Gas Control. https://doi.org/10.1016/j.ijggc.2011.06.005

Upreti, B.R., 2004. Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales. Energy Policy 32, 785–800.

Upreti, B.R., van der Horst, D., 2004. National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant. Biomass and bioenergy 26, 61–69.

van Alphen, K., van Voorst tot Voorst, Q., Hekkert, M.P., Smits, R.E.H.M., 2007. Societal acceptance of carbon capture and storage technologies. Energy Policy 35, 4368–4380. https://doi.org/10.1016/J.ENPOL.2007.03.006

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, 2705–2714.

Vera Castillo, Y.B., Pritchard, H.W., Frija, A., Chellattan Veettil, P., Cuevas Sanchez, J.A., Van Damme, P., Van Huylenbroeck, G., 2014. Production viability and farmers' willingness to adopt Jatropha curcas L. as a biofuel source in traditional agroecosystems in Totonacapan, Mexico. Agric. Syst. 125, 42–49. https://doi.org/10.1016/J.AGSY.2013.12.003

Von Maltitz, G., Gasparatos, A., Fabricius, C., Morris, A., Willis, K., 2016. Jatropha cultivation in Malawi and Mozambique: impact on ecosystem services, local human well-being, and poverty alleviation. Ecol. Soc. 21.

Walker, G., 2010. Environmental justice, impact assessment and the politics of knowledge: The implications of assessing the social distribution of environmental outcomes. Environ. Impact Assess. Rev. 30, 312–318. https://doi.org/https://doi.org/10.1016/j.eiar.2010.04.005

Wallquist, L., Seigo, S.L., Visschers, V.H.M., Siegrist, M., 2012a. Public acceptance of CCS system elements: A conjoint measurement. Int. J. Greenh. Gas Control 6, 77–83. https://doi.org/https://doi.org/10.1016/j.ijggc.2011.11.008

Wallquist, L., Seigo, S.L., Visschers, V.H.M., Siegrist, M., 2012b. Public acceptance of CCS system elements: A conjoint measurement. Int. J. Greenh. Gas Control 6, 77–83. https://doi.org/https://doi.org/10.1016/j.ijggc.2011.11.008

Webler, T., 1995. 'Right' discourse in citizen participation: an evaluative yardstick, in: Fairness and Competence in Citizen Participation. Springer, pp. 35–86.

Webler, T., Kastenholz, H., Renn, O., 1995. Public participation in impact assessment: a social learning perspective. Environ. Impact Assess. Rev. 15, 443–463.

West, J., Bailey, I., Winter, M., 2010. Renewable energy policy and public perceptions of renewable energy: A cultural theory approach. Energy Policy 38, 5739–5748. https://doi.org/10.1016/j.enpol.2010.05.024

Whitmarsh, L., 2011. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. Glob. Environ. Chang. https://doi.org/10.1016/j.gloenvcha.2011.01.016

Whitmarsh, L., Corner, A., 2017. Tools for a new climate conversation: A mixed-methods study of language for public engagement across the political spectrum. Glob. Environ. Chang. https://doi.org/10.1016/j.gloenvcha.2016.12.008

Witkamp, B., van Gijlswijk, R., Bolech, M., Coosemans, T., Hooftman, N., 2017. The transition to a Zero Emission Vehicles fleet for cars in the EU by 2050. Pathways and impacts: An evaluation of forecasts and backcasting the COP21 commitments. Brussels.

Wolsink, M., 2007. Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. Energy Policy 35, 2692–2704.

Wolsink, M., 2006. Invalid theory impedes our understanding: a critique on the persistence of the language of NIMBY. Trans. Inst. Br. Geogr. 31, 85–91.

Wolsink, M., 2000. Wind power and the NIMBY-myth: institutional capacity and the limited significance of public support. Renew. energy 21, 49–64.

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

Zhang, Y., Yu, Y., Zou, B., 2011. Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. Energy Policy 39, 7015–7024. https://doi.org/https://doi.org/10.1016/j.enpol.2011.07.055

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This report reviews different models and frameworks that explain public responses to low carbon technologies (LCTs). Based on insights from literature, it highlights the need for a multidimensional perspective to understand the complexities surrounding public acceptance of or opposition to LCTs. It also proposes two key solutions for how public responses can be better accommodated in a way that engenders support from the public: by integrating social and values-based aspects in planning, and by ensuring procedural justice in technology deployment. Reflecting on these, policy options are drawn for how these solutions might help contribute to delivering better approaches in engaging the public in the low carbon transition.

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