“An economic analysis of wind farm externalities and public preferences for renewable energy in Ireland”

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<u>For the Attention of Lucy Corcoran</u>

Executive Summary

In Ireland the deployment of onshore wind turbines has become progressively more difficult in some areas because of the potential negative externalities associated with their operation. Using a discrete choice experiment (DCE) we employ a willingness to accept framework to estimate the external effects of wind turbines on local residents with the inclusion of community engagement to measure the compensation required to permit wind farms to be built in Ireland. We find that the majority of respondents to be generally in favour of wind energy. Respondents show less support for wind farms developed for export. Experience of a local wind farm does not appear to have altered participant attitudes. Respondents were asked if their opinions had changed over time regarding their local wind farm. The general trend is one of no change, although respondents who were very positive about their local wind farm became more positive through time. The experience local stakeholders have had regarding a local wind farm is an important issue. Respondents were asked whether the local wind farm developer cooperates, provides financial benefits or information to local residents. Most respondents are either neutral or appear to strongly agree that developers do engage with local residents with respect to these issues. With respect to ownership of the wind farm and different ownership models respondents held a preference for Irish farmers local to the area and semi state companies.

Regarding the estimation of externalities our findings reveal that the majority of respondents are willing to make (monetary) trade-offs to allow for wind power initiatives. Respondents are sensitive to setback distance in Ireland and our results suggest that if the distance were increased from 500m to 1000m the respondent would require €337.63 less in compensation per annum (in the form of a discount to their electricity utility bill).

However, we note that community engagement is a very important issue. We find that respondents require less compensation if provision is made for comprehensive levels of engagement.

Key words: Public preferences, Wind farm externalities, Discrete Choice Experiment, Focus groups, Export.

Introduction

The Republic of Ireland (RoI) has a number of ambitious renewable energy targets that will be met mainly through the deployment of onshore and offshore wind energy. A number of important policy documents including The 2007 White Paper; "Delivering a sustainable energy future for Ireland" stipulate the activities and plans required to achieve these targets and also mention the wider societal and policy objectives including enhancing social acceptability, community engagement, employment, stakeholder consultation and development opportunities that can underpin wind energy initiatives. Despite the rapid growth of onshore wind farm development and the controversial nature of some individual onshore wind farm projects in Ireland and their impact on local communities, apart from a few exceptions (Brennan and van Rensburg, 2015; Brennan et al., 2017) relatively few studies have examined the economic costs and benefits and external effects of onshore wind farms and in the case of offshore wind farms these issues have not been investigated at all in Ireland. Consequently it is difficult for policy makers to gauge the impact of onshore and future offshore wind farms on communities or to evaluate the potential future growth of onshore versus offshore wind in the energy portfolio.

Market economies work well but they do not work perfectly and markets sometimes fail. Market failure occurs when markets fail to deliver an efficient allocation of resources – when there is a divergence between the outcome of competitive markets and what is desirable from society's point of view. The main causes of market failure are market power (i.e. monopoly), externalities, public goods and asymmetric information. Economists model this market failure in two ways – using the public good model and the theory of externalities, both of which are linked to the concept of property rights. Externalities are a significant and important source of market failure. Externalities occur "when the actions of one agent have an unintended effect on some other agent or agents" and these agents "neither receive compensation for harm done nor pay for benefits gained" (Hanley, Shorgen & White, p 49). Externalities can be positive or negative and can occur at consumption or production. Externalities are not traded in the market and are not captured in the market price of commodities. Market prices therefore act as a poor signalling mechanism and result in the misallocation of scarce resources. There is evidence to suggest that consumers in general are willing to pay a premium for positive externalities associated with renewable energy (Longo et al., 2008). Despite this there is evidence to suggest that individual wind farm projects in many areas, Ireland included, have faced significant local resistance. Consequently substantial research has been devoted to questions regarding their social acceptability and the negative externalities associated with their operation (Heintzelmen and Tuttle, 2012; Brennan and van Rensburg, 2015). Localised negative externalities come in different forms and include landscape and biodiversity (Ladenburg and Dubgaard, 2007), noise pollution and shadow flicker (Devine-Wright, 2005) and declining residential property prices (Heintzelmen and Tuttle, 2012). Wind farm externalities are not confined to domestic generation and also include the trade in renewable energy exports (Cleary et al., 2016) and a recent study in Ireland indicates that opposition to wind farms by local stakeholders is greater for export projects compared to initiatives for domestic use (Brennan et al., 2017). Social costs and external effects associated with energy exports may differ compared to domestic energy use in Ireland and yet no attempt has been made regarding their estimation.

In Ireland the issues raised above are subjects of national political debate and are a priority for policy makers charged with expanding Ireland's renewable energy portfolio since externalities impacting on stakeholders arising from REE projects leads to an inefficient allocation of resources, puts at risk Ireland's comparative advantage in renewables, its ability to export renewable energy and generally gives rise to considerable uncertainty for REE operators regarding the future deployment of REE projects.

Recent proposals by the DCCAE (2017) set out a number of new initiatives regarding community engagement as part of the proposed Renewable Electricity Support Scheme (RESS). These include benefit schemes, increased consultation between developers and communities and use of a trusted intermediary. Questions still remain as to the relative efficacy, cost, economic efficiency and distributional issues raised by these different community engagement initiatives.

This study uses survey data conducted nationally to quantify externalities and better understand the welfare implications of wind farm projects as well as public attitudes and economic behaviour associated with offshore and onshore wind farm in the RoI. It evaluates whether community interventions such as enhanced interaction, and community engagement influence social acceptance and it explores possible differences between domestic energy consumption and trade. It provides information which can contribute toward the evaluation of community engagement under the proposed RESS and generally makes recommendations to enhance the future efficacy of renewable energy provision from wind farms in the RoI.

The main project objectives are listed below.

Project objectives

1. To determine the main externalities associated with onshore and offshore wind farms in Ireland;
2. To investigate public understanding, awareness and attitudes towards wind farm projects, in relation to both outcome fairness, process fairness and the availability of non-biased information; and identify the main barriers to social acceptance;
3. To evaluate the effects of knowledge, experience and demographic factors on the social acceptance of onshore and offshore wind farms;
4. To evaluate to what degree local communities are willing to accept (WTA) compensation for wind farm production in their area, and how this varies according to key attributes of developments and perception of externalities;
5. To identify whether best practice, transferable community interventions, including appointment of community representatives,non-biased information provision and enhanced community interaction can enhance social acceptance of renewable energy adoption.
6. Determine the factors that have contributed to social acceptance of WF at a local level

A number of key themes have emerged from this research which relate to social acceptance of wind farms, externalities and their valuation, stakeholder participation, distributive and procedural justice, focus group findings, an explanation of main sections of the surveys and details of the choice experiment used to value external effects. This is followed by results of the study and conclusions. We begin with a brief review of the literature is given as background to the study.

Distributive and procedural justice:

The previous section highlights the importance of welfare effects regarding wind farm development. These elements are particularly important in the context of renewable energy development are known as: distributive justice, which relates to the equitable distribution of benefits; and procedural justice, which concerns whether or not the process of development is viewed as being fair (Gross, 2007; Agterbosch et al. 2009; Hall et al. 2013).

Walker and Devine-Wright (2008) outline these aspects of fairness in planning and outcomes by indicating a space within which a commercial or community wind farm might operate:

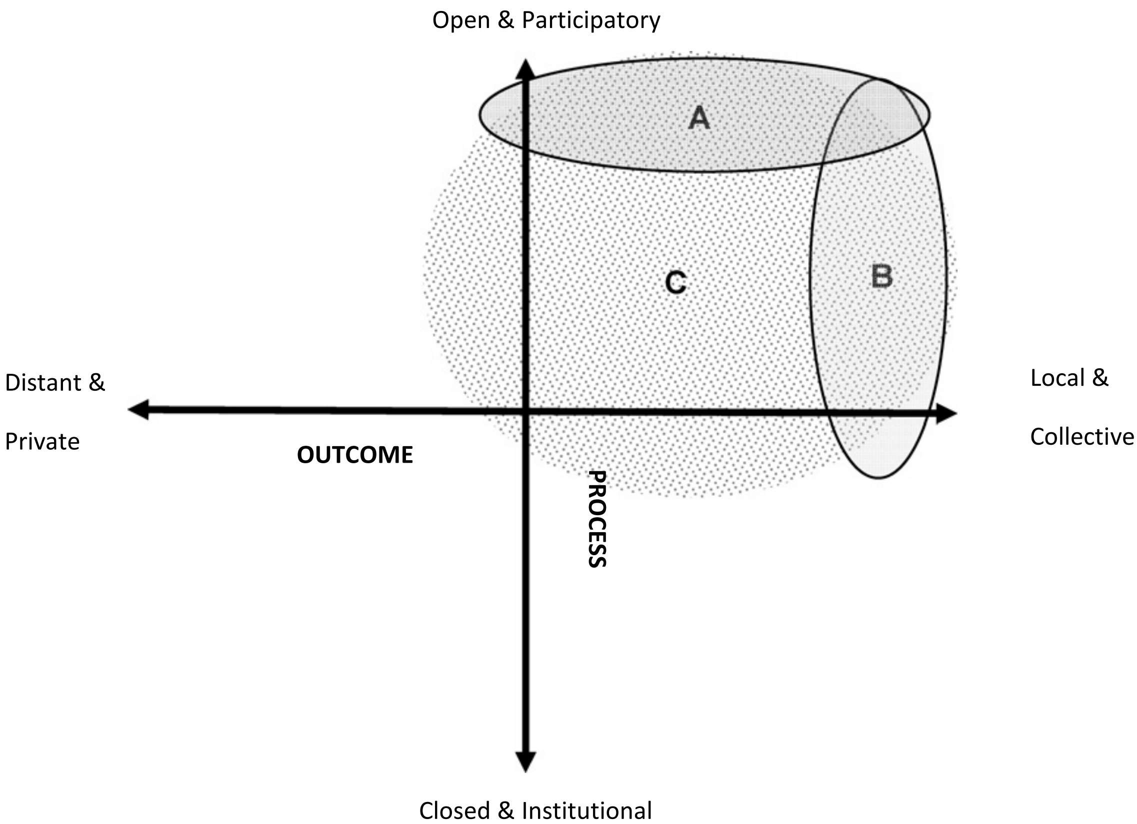

Figure: Understanding of community renewable energy in relation to project process and outcome dimensions (Walker and Devine-Wright, 2008).

The vertical *process* element focuses on who develops and operates the wind farm and who can make decisions and have influence over the project. The process can range from one which is *open and participatory*, representing a wind farm that is transparent in its implementation and planning processes, incorporating the opinions and influences of a wide range of stakeholders; to one which is *closed and institutional*, with only the private operators having influence over the wind farm's operation.

The horizontal *outcome* element relates to the beneficiaries of the project, economically or socially. These benefits can range from those which are *local and collective*, with the majority of the benefits accruing to those in the vicinity of the wind farm to those which are *distant and private* at the other extreme, with most of the benefits being received by operators or owners who do not have any connection to the area within which the wind farm is located. A traditional privately operated wind farm would be located in the bottom left of the space whereas a “community” wind farm would be located on the top right. Community projects could be those which have high levels of involvement from local residents in the establishment and running of the project (A) or those which place the majority of the benefits of the project primarily in the surrounding area of the wind farm (B). A project which leads to some productive outcome for the locality, regardless of the extent of these benefits or the degree of involvement from residents, could also be considered a community project (C).

Cowell et al. (2012) indicate that wind energy developments create impacts on those around them that are considered to be negative. They also note that the distribution of these negative externalities are not shared equally by those in society and instead are focussed primarily on those closest to the turbines. These areas tend to be places that have experience in environmentally damaging activities such as coal mining, oil and gas exploitation. Many of these rural areas are also economically disadvantaged, with higher levels of isolation, deprivation and aging populations. While the provision of benefits could therefore be seen to engender social acceptance and demonstrate “good neighbourliness”, the authors recommend that the provision of benefits should be viewed instead as a method of increasing justice for those in the surrounding area of a development who disproportionally bear the costs of the project.

Hall et al. (2013) also note the importance of distributive justice, with respondents in their study suggesting methods for a more equitable distribution of project benefits for residents in the wider community. If the method of benefit provision is viewed as unjust then this can lead to social divisions. This study also highlights the importance of procedural justice, with respondents having strong preferences for planning processes that include open, participatory and transparent elements. The Figure below outlines the forms of engagement community respondents requested in this study, from the pre-proposal stage to the finished project.

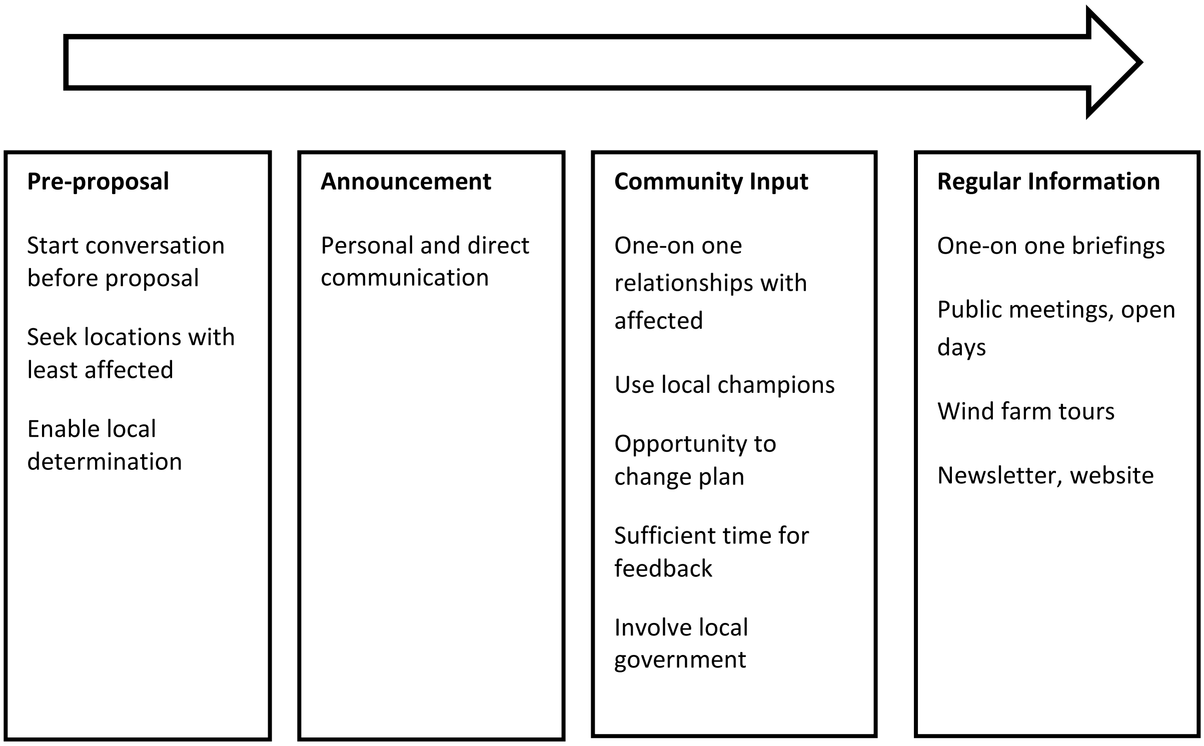

Figure: Consultation stages recommended (Hall et al. 2013)

In order to achieve procedural justice, local residents need to be involved actively in engagement processes and have real and significant influence over the decision making process (Hall et al. 2013).

Due to perceived injustice in wind farm planning procedures, Ottinger et al. (2014) propose a collaborative governance (CG) model, within which stakeholders construct the governance characteristics of the deliberative process. This could involve professionally conducted meetings with a wide range of stakeholders including residents, developers, local official etc. The developer’s plans would be inputs into the deliberation process and would not be set in stone. Instead, developers would be expected to revise these plans subject to the concerns of residents. This process would represent rung 7 (delegated power) on Arnstein's ladder of citizen engagement outlined in the next section.

Gross (2007) outlines a community fairness framework which aims to increase the societal acceptance of wind energy. Respondents in her study were dissatisfied with the level of information provision, the degree of real engagement and the quality of interaction from wind farm developers. This work suggests that there are three types of fairness that matter: outcome favourability; outcome fairness and process fairness. Outcome favourability relates to the distribution of benefits and project outcomes, this affects the "winners", "losers" and those morally in favour or opposed to the development. These individuals either receive a personal benefit/ loss with the project outcome or have a strongly held belief in the project outcome. Outcome fairness also relates to distributive justice but impacts the "neutrals" and the "silent majority" who may not have an opinion but prefer that the outcome is fair in order to maintain social wellbeing. Lastly, process fairness relates to procedural justice and impacts the entire community as a fair process is more likely to lead to a just outcome (Gross, 2007).

These studies highlight the importance of distributive and procedural justice in terms of the community acceptance of wind energy. A key component of this perception of a fair process is engagement and interaction between local residents and wind farm developers a subject to which we now turn.

Arnstein's ladder of citizen participation

Arnstein's 1969 work on social programs in the US highlights a broad spectrum of community participation, and provides a framework by which true meaningful engagement can be classified. She identifies citizen participation as the redistribution of power from the “haves” (the wealthy, those in power) to the “have nots” (the poor, minorities, those lacking power). Participation allows the “have nots” to make decisions about how planning decisions are undertaken, the information provided and the distribution of benefits. In this work, she provides 8 stages or “rungs” on a ladder of citizen participation.

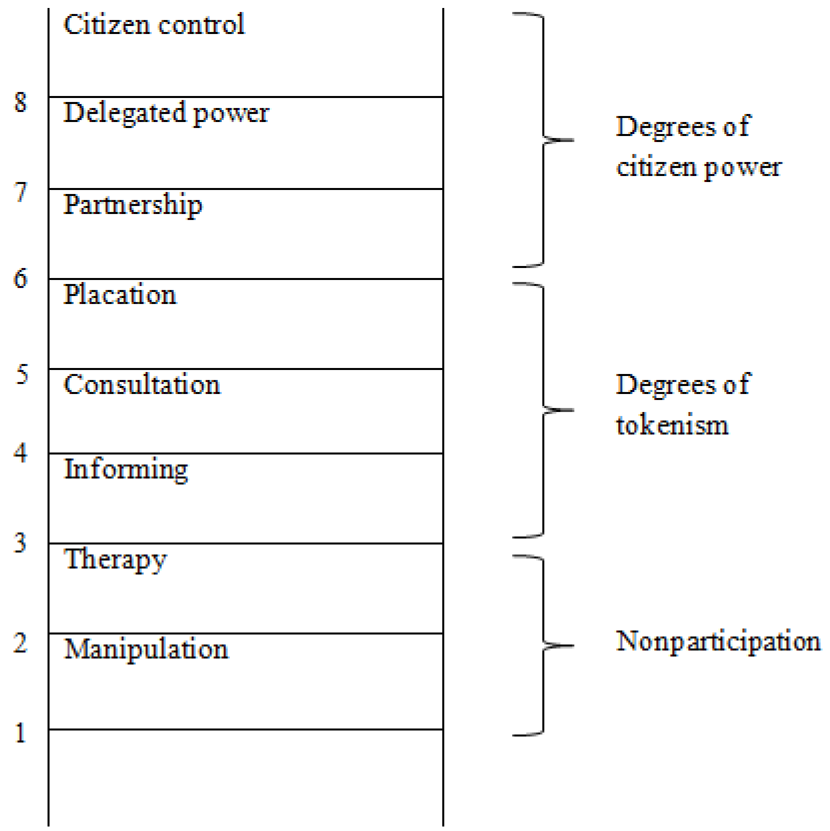

Figure: Arnstein’s ladder of citizen participation (Arnstein, 1969)

This framework can be used to classify the type of community engagement carried out by wind farm developers. The bottom rungs of the ladder are manipulation and therapy. These types of engagement are regarded as “non-participation” as their goal is not to provide the public with control over the process but rather to “educate” or “cure” them of their beliefs. This could occur in wind farm developments where members of the public in the surrounding area are not informed about the full scale of the project or where advisory meetings are really exercises in support gathering.

The next three rungs are considered “tokenism”. They allow members of the public to have their say but the “haves” retain the final decision-making power. Informing residents is regarded as the first true stage towards citizen participation. This stage does not allow for resident feedback. In wind farm developments, this stage may involve the provision of newspaper articles, flyers and posters about the project and basic responses to inquiries. Public meetings may be one-way if they provide basic information and discourage questions.

The next rung, consultation still does not guarantee that the public’s opinion will be taken into account. This stage in a wind farm development may involve attitudinal surveys, local meetings and public forums. Residents who engage in consultation achieve nothing more than “participation in participation” and developers have performed a box-ticking exercise.

The first stage that allows citizens some influence is placation, though this is still regarded as tokenism. At this stage, a select resident may be chosen to act on a public board or in a decision making position, though he/she can easily be outvoted or bullied into submission by the power holders.

Rungs 6-8 signify levels of citizen power. At the partnership stage, power is redistributed through negotiation. This can occur in wind farm developments where the developer and community actively engage and negotiate over the planned project. This occurs best when the community is organised and has the financial capabilities and time to organise its own experts and leaders.

Rung 7 represents the stage at which the residents have more decision making power than the traditional “haves”. When this occurs, the “haves” must bargain with the citizens rather than only engaging once under pressure from residents. In this situation, a wind farm developer may approach a community with a proposed development prior to the planning stage and open to negotiation, rather than announce a project post-planning as a fait accompli.

The final rung on the ladder of citizen participation is citizen control. At this stage, residents have the power to govern a program or development, are in charge of policy and managerial characteristics and can negotiate fully with any “haves” involved. In wind farm development, this level of participation may take the form of a community wind farm. This may still involve development and construction by private wind farm developers but residents can engage meaningfully with the private developers throughout the planning, construction and operational phases of the project. Residents have the final say over the scale and location of the project, how it is run and to whom the benefits are distributed (Arnstein, 1969).

Focus Groups

The focus groups are extremely important in providing a qualitative dimension to the study which will be used to investigate public understanding, awareness and attitudes towards wind farm projects, in relation to both outcome fairness, process fairness and identify the main barriers to social acceptance. Secondly they are very valuable in providing information for the choice experiment. In what follows we elaborate on these ideas by providing a short explanation of what they are, what they do how they can be used effectively and finally we provide details on the number of focus groups and specify their locations.

The origin of focus groups can be traced back to the 1940's when Merton first introduced the concept of the "focused interview" as a reaction to poor scientific standards in the marketing field, which tended to lead subjects to a predetermined conclusion. The qualitative data from his research at this time indicated that interaction between subjects could result in more elaborative results (Merton, 1987). This interaction, based on attitudes and experience is of key interest to researchers (Morgan and Spanish, 1984).

Not all focus groups seek to generate the same types of information and so the distinction should be made between the different kinds of research being conducted. Calder, 1977 distinguishes between three separate types of qualitative research approaches: exploratory, clinical and phenomenological. The exploratory approach incorporates focus groups that are conducted as a type of "pilot testing". This type of research is commonplace at the outset of non-market wind farm valuation studies using stated preference techniques such as choice experiments of the type used here (Ek and Persson, 2006; Champ and Bishop, 2001; Álvarez-Farizo and Hanley, 2002). The selection of choice set attributes is a crucial stage in the methodology and a thorough literature review and pilot study including focus groups is recommended. (Pearce and Özdemiroglu, 2002). This is one of the reasons why we have placed emphasis in ensuring we have enough of them and obtain a good representation across the country in both an onshore and offshore context (see the locations of focus groups listed below).

The focus groups may also be used to check the wording of a survey or to clarify hypothesis and tend to be moderated in an unstructured fashion where open discourse amongst participants is encouraged. In this sense the researcher hopes to create scientific theories from the everyday knowledge of the subjects. This involves the notion of “grounded theory” which means that a theory has evolved from qualitative and quantitative research. This type of focus group serves as a starting point for further scientific research and should not be used to provide stand-alone conclusions, however they can also be used after quantitative research to confirm or clarify results. The clinical approach serves to counteract the weaknesses of self-reported responses in quantitative research which may not reveal the true causes of behavior. This approach seeks “depth” in responses and requires a skilled moderator to guide respondents to reveal their true feelings. The final phenomenological approach requires the moderator to observe respondents so closely that he or she almost becomes one of them. This approach is most commonly used in the field of sociology where moderators become involved in the lives of their subjects and share their experiences (Calder, 1977).

It is crucial for respondents to firstly find a common ground for discourse. This commonality means that they are acting and responding as a group; if this does not happen then these respondents are simply answering as individuals who share a common focus. Once this cohesion is established the respondents can then add their contributions to the commonality. They can do this by creating a narrative together or by referring to previous respondents discussions thereby strengthening the bond of the group (Hydén and Bullow, 2003). Interaction among participants can also take the form of interruptions, requesting or providing comparisons or by resolving differences through debate (Morgan and Spanish, 1984).

The information generated in a focus group differs to that provided by other forms of qualitative methods like individual interviews and these methodologies are complementary, not substitutes. Controversial or sensitive information is often easier to reveal through individual interviews, whereas focus groups provide a forum for in-depth discussion on a host of issues and an ideal setting for sourcing new information and ideas (Kaplowitz and Hoehn, 2000). Focus groups can be conducted as a stand-alone research exercise to analyse attitudes and opinions or in tandem with survey research, experiments or other qualitative methods to “triangulate” research (Morgan and Spanish, 1984). Focus groups can be used to confirm quantitative results or to clarify apparent contradictions (Wolff et al, 1993). We now focus on background explaining the role of stated preference studies and non-market valuation used to estimate wind farm externalities.

Externalities and Non-market valuation: choice experiments:

Stated preference studies allow researchers to assess the demand for environmental protection, ecosystem services, local wind farm externalities through the use of surveys by analysing consumer preferences for a hypothetical situation offering a change in these services. These techniques differ to revealed preference studies in that both use and non- use values can be captured. The two main types of stated preference techniques are contingent valuation which asks consumers their willingness to pay or willingness to accept for a change in an environmental good or service and choice modelling in which respondents choose between two or more situations with shared attributes of the good in question but with different levels of these attributes (Pascual et al. 2010).

While contingent valuation studies have analysed the WTA and WTP for wind farm developments (Georgiou and Areal, 2015; Du Preez et al. 2012; Groothuis et al. 2008), the methodology can suffer from biases whereby respondents often answer the valuation question in a way they believe would please the interviewer, not reflecting their own true values (Carson et al. 2000).

Choice experiments fall under the umbrella term “choice modelling”, which includes techniques such as contingent ranking, within which respondents rank alternative outcomes in order of preference; contingent rating, where options are not compared to each other but independently scored on a predetermined scale; and paired comparison, whereby the respondent selects the preferred option and scores it on a predetermined scale (Alriksson and Öberg, 2008). In general, it is more difficult for respondents to answer strategically in a study with choice experiments than it is in a contingent valuation situation because of the difficulty involved in such deception due to the changing attribute levels in each choice set (Alpizar et al. 2003).

Designing choice experiments:

The selection of choice set attributes is a crucial stage in the methodology and a thorough literature review and pilot study including focus groups is recommended. One of the attributes selected should be a monetary value to act as a payment vehicle. As a general rule, no more than four or five attributes should be selected, including the cost attribute (Pearce and Özdemiroglu, 2002). Next, the levels associated with these attributes are decided. These levels should represent the policy and research goals within realistic bounds. More levels can result in a greater understanding of the relationship between an attribute and marginal utility but can increase the complexity and size of the design, leading to the requirement for a much larger sample size. In general 3 to 4 levels are sufficient. A status quo opt-out option can be included to add realism, especially in willingness to pay situations where a consumer cannot be forced to purchase, however, if the changes provided by the choice options are inevitable an opt-out may not be suitable. A full factorial design is then implemented which contains all of the possible combinations of attribute levels for each option. This usually results in a large and unwieldy number of choice sets. An optimal experimental design is then chosen in order to combine the various attributes and possible levels without requiring huge numbers of choice sets, the most frequently used of which is the fractional factorial design. This uses a section of the full factorial design while still retaining as much of the statistical properties of the full design as possible. Generally this takes an orthogonal form, where changes in the attributes in each option are uncorrelated in each choice set. The choice sets are then constructed and may be split into blocks in order to reduce the cognitive burden on each respondent. In general, about 8 choice sets per individual is considered reasonable, however as few as 1 and as many as 16 have been successfully conducted.

Once a survey has been designed, including the choice sets, focus groups are generally conducted in order to test for clarity and methodological issues, followed by pilot surveys (Pearce and Özdemiroglu, 2002). The main survey should include a section providing context to the study at hand, and the choice set section should be preceded by instructions for respondents with thorough explanations of the attributes and levels. Debriefing questions can provide insight into the motives behind respondent’s choices and are particularly useful for capturing lexicographic preferences, cognitive bias and protest motives.

Limitations of choice experiments:

Choice experiments can suffer from many of the same biases and issues that affect contingent valuation studies but most of these issues can be accounted for through rigorous design and testing. Hypothetical and strategic bias can occur when respondents do not believe the choice set scenario presented to them or believe that their WTP amounts won’t really be collected. This can be prevented with thorough pilot testing in order to ensure that the scenario is plausible (Pearce and Özdemiroglu, 2002). Heterogeneity is difficult to analyse using Standard Random Utility Models (RUM) and so researchers can avail of interaction techniques or mixed logit models, such as the RPL model which allows model parameters to vary over individuals. Framing affects can occur when the choice scenario is presented in an overly positive or negative light. This can be prevented by describing the scenario in a neutral way and testing for effects with focus groups (Pearce and Özdemiroglu, 2002). Payment vehicle bias occurs when the WTP or WTA for a good depends on the method of payment, e.g. tax, electricity bill discount. Focus groups can be used to establish the appropriate payment vehicle, which should be the one most likely to be used in reality (Pearce and Özdemiroglu, 2002). The omission of a status quo option can cause inaccurate welfare results for non-marginal changes (Alpizar et al. 2003), however the decision to include an opt-out alternative must be guided by the reality of the situation and it may not always be suitable to include it (Adamowicz and Boxall, 2001). Choice task complexity and respondent fatigue can also be an issue (Adamowicz and Boxall, 2001) but with minimal design of no more than 5 attributes and about 8 choice sets, these issues can be avoided (Bateman et al. 2002; Adamowicz et al. 1998). Respondents can also be asked to think out loud when completing the choice sets in order to engage the individual with the task and test their understanding (Alpizar et al. 2003). As with contingent valuation, choice experiment studies can suffer from embedding and scope insensitivity issues, where the WTP/WTA does not change with different amounts of the good in question. In this sense, WTP may represent the "warm glow" associated with payment for the good and not the true WTP for the good itself. There is debate about whether this is a problematic issue at all (Hanemann, 1994), however follow up questions can be used to establish respondents motives

(Pearce and Özdemiroglu, 2002). Similarly, protest responses, whereby respondents refuse to engage with the choice task can be tested for through appropriate follow up questions to elicit motives, and protesters can be removed from the analysis (Pearce and Özdemiroglu, 2002).

Empirical specification:

The theoretical framework underlying choice experiments is random utility theory which suggests that a good can be assessed in terms of the attributes it contains and the levels of these attributes, e.g. a wind farm could be valued in terms of the number of turbines, height, setback distance etc. (Pearce and Özdemiroglu, 2002). Choice experiments differ from contingent valuation in the sense that individuals choose from a range of options and select the one that results in the greatest utility for them, as opposed to providing a value for one fixed option (Adamowicz and Boxall, 2001). The utility derived from the selection of an option depends on its attributes, the utility function of the respondent and an unobservable element. Generally, a monetary attribute is included, therefore when respondents decide on their optimal choice they make implicit trade-offs between the attribute levels and the different options in the choice set (Alpizar et al. 2003).

Following Adamowicz and Boxall (2001), an individual's utility can be described as:

$$U = V + \varepsilon$$

where V is the indirect utility function containing the attributes and ε describes this unobservable stochastic element . V can then be broken down further:

$$V_j = \beta_k X_j$$

where X is a vector of k attributes related to option j, e.g. height, setback distance etc. and β is a coefficient vector.

The conditional choice probability of selecting alternative j is:

$$Prob\ (j) = \frac{\exp(\mu\beta_k X_j)}{\sum_{i\epsilon C}\exp(\mu\beta_k X_i)}$$

where μ represents a scale parameter and C the choice set. In this situation μ is combined with the parameter vector and cannot be isolated (Adamowicz and Boxall, 2001).

The Multinomial Logit (MNL) model can account for some *observed* heterogeneity by assuming that utility is a function of individual specific variables Z_i , which vary across respondents but are constant across choices, and X_i which are specific to each option (Caporale and De Lucia, 2015):

$$U_{ij} = Z_i X_i + \varepsilon_{ij}$$

This assumes that the utility an individual derives from wind farms depends on the characteristics of the proposed wind farm (attributes), individual characteristics and unobserved idiosyncrasies, represented by a stochastic component. The multinomial logit (MNL) framework assumes that unobserved factors which may impact the choice of alternatives are strictly independent of each other, that is, the odds of choosing alternative j over alternative $j^{'}$ do not depend on the other alternatives in the choice set (Independence of Irrelevant Alternatives, IIA). This may not actually be the case. It is possible that unobserved factors that impact on the utility from wind farm A

B or the status quo option are correlated with the observable factors included as attributes.

The restrictions of the MNL model are relaxed in the random parameter logit (RPL) model. The latter is more generalised and allows unobserved factors to be random and follow any (normal, lognormal, uniform etc.) distribution. The RPL model is not restricted by the IIA limitation associated with the MNL model and it explicitly accounts for heterogeneity in the results (McFadden and Train, 2000). In the RPL model one or more taste parameters are treated as random parameters. The random parameters produce a distribution around the mean that provides a means of revealing unobserved heterogeneity in the sampled population (Ghosh et al., 2013).

The description of the theoretical framework applied in this study for deriving a respondent's WTA is provided below.

In each choice set, the respondent faces a choice between a set of three alternatives: Wind farm option A and wind farm option B define two wind farms with different attribute levels whilst option C represents the status quo option (no new wind farm). An individual is assumed to choose the option from each choice set that gives them the highest utility. This choice can be seen as the probability of choosing option A, B or C and so this choice is analysed using the logit framework.

In general, a respondent q's utility from choosing alternative *j* in choice situation *t* in a random utility function with random parameters can be defined as:

$$U_{jtq} = V_{jtq} + \varepsilon_{jtq} \equiv \beta'_{qk} X_{jtqk} + \sigma'_{k} z_{q} X_{jtqk} + \varepsilon_{jtq} \quad (1)$$

where respondent q (q=1,….Q) obtains utility U from choosing alternative j (Option A, B or C) in each of the choice sets t (t=1,…12). The utility has a non-random component (V) and a stochastic term (ε). The non-random component is assumed to be a function of the vector of k choice specific attributes: X_{jtqk}, with corresponding parameters β_{qk} which may vary randomly across respondents due to preference heterogeneity with a mean β_k and standard deviation σ_k. There are 6 attributes in this vector, TURBINES, HEIGHT, SETBACK, CITIZEN CONTROL, EXPORT and COMPENSATION and the alternative specific constant (ASC) representing the status quo option (this takes a value of 1 when the respondent chooses the option of no new wind farm). The ASC also captures all the attributes erringly excluded from X_{jtqk} and the utility associated with not choosing the status quo. It is assumed that the individual chooses the option j that provides them with the highest utility.

In the RPL framework preferences are allowed to vary across individuals and coefficients are characterised by a distribution which depends on certain parameters e.g. the mean and covariance of the distribution. By introducing individual specific characteristics, z_q, sources of preference heterogeneity can be identified. These variables are interacted with the choice-varying attributes X_{jtqk} . The RPL model described above will therefore identify two types of variation in preferences, the variation associated with individual specific characteristics (e.g. income) and a random, unobservable and unconditional preference heterogeneity captured by the standard deviation σ_k of the distribution of each random parameter β_{qk}. If this standard deviation is statistically significant, than the coefficient does actually vary across individuals, as opposed to the MNL model where homogenous preferences are assumed for all respondents. Given a specific distribution these parameters can be estimated by a simulated maximum likelihood estimator using Halton draws.[1]"

Two survey instruments have been developed as part of the study. Both involve the use of choice experiments. These include an onshore survey targeted at 250 respondents and an offshore survey targeted at 250 respondents. Some background on both the surveys is detailed below.

Survey design and methodology

Onshore Survey

The onshore survey is 28 pages in length and includes 4 main sections. The first part of the survey examines general attitudes towards environmental issues and wind energy. Previous work has established that those with an interest in "green" issues are more likely to be in favour of wind energy in Sweden (Ek, 2005) and so a question is included to test the effect for Irish respondents. The first question in the survey asks respondents to rank on a scale of 1 (very unimportant) to 10 (very important) the importance of environmental issues to them. Examples of environmental issues are given including pollution, recycling and climate change.

[1] Halton draws are "pseudo-random" sequences that simulate independent draws from a uniform distribution and are more efficient than standard random draws. It is recommended that a range of Halton draws are used from between 100-2000 draws (Hensher et al., 2005).

The Strategy for Renewable Energy 2012-2020 claim that significantly more wind farms, both on and offshore, will need to be constructed in order to achieve 2020 targets through wind (DCENR, 2012). This section in the survey identifies if the respondents are favourable towards onshore wind farm development, offshore wind farm development and the construction of wind farms for exportation project and whether or not respondents believe there are enough wind farms in Ireland.

Wind farm developers may assume that increased knowledge and education around wind energy will increase acceptance (Brennan et al., 2017), however the literature on this topic is unclear about this, with some noting mild increases in positive attitudes (Wolsink, 2007). To test for this effect, a question has been included to establish the Irish public's current knowledge on wind energy in general. This is achieved by asking respondents to answer "True" "False" or "Don't Know" to a number of correct and incorrect statements about wind turbines.

Section B in the survey requests information on respondent's local wind farm, either in construction or in place and speaks to aims of the study regarding best practice.

Previous studies have found that attitudes towards wind energy can change from positive in the pre-planning stage, to negative following the announcement of a wind farm to even more positive than before once the development is established (Wolsink, 2006). Respondents are asked how far they live from their nearest wind farm and to think back to the construction stage and rank their feelings about the development from 1 (very negative) to 10 (very positive). This is similar to the technique used by Eltham et al. (2008) in their study in the UK.

Maruyama et al. (2007) find that the owning a share in a wind farm project can increase community acceptance and several studies have found that the acceptance of wind energy is strengthened if residents believe they benefit from the development (Bidwell, 2013; Chen et al. 2015; Caporale and De Lucia, 2015; Guo et al. 2015). This section of the survey also includes questions relating to the respondents willingness to purchase shares and the local and personal benefits which arise from this wind farm.

Trust in the process and outcomes of a wind farm development can be crucial in terms of acceptance (Walker and Devine-Wright, 2008; Hall et al. 2013; Gross, 2007; Cohen et al. 2014). A question is included to determine whether their local wind farm developer cooperated, provided information and financial support to the local community in order to establish “best practice” areas.

Finally, individuals are asked to rank how they feel about the development *now*, from a scale of 1 (very negative) to 10 (very positive). This returns back to the questions seeking to establish the change in feeling about the wind farm over time.

Section C begins with an introduction to the wind farm choice sets. Stated preference studies allow researchers to assess the demand for environmental protection or ecosystem services through the use of surveys by analysing consumer preferences for a hypothetical situation offering a change in these services. One of the main types of stated preference techniques is choice modelling in which respondents choose between two or more situations with shared attributes of the good in question but with different levels of these attributes (Pascual et al. 2010).

This section establishes that this would be a new on or offshore wind farm in their area (depending on the survey area) and would be in addition to any wind farms that already exist. The attributes are then introduced to the respondents. The attributes identified include electricity discount, number of turbines, setback distance, community control and export. A choice card for the offshore survey is indicated below.

Follow up questions to the choice sets will be asked to probe for difficulty in responding (Boxall et al., 2009), ignoring attributes (Meyerhoff and Liebe, 2009; Lanz and Provins, 2015) and protest responses (Pearce and Özdemiroglu, 2002).

In recent years, a number of studies have shown that there is an increasing interest in the trade in renewable energy exports (REE) between EU countries (EC 2014; IWEA 2012; DCENR 2012). A recent study has suggested that the Irish public may have negative attitudes towards the exportation of wind energy (Brennan et al., 2017) and so a question is included to explore the concept of exportation in relation to national and local benefits.

The construction of wind turbines can result in fears over the potential health, property value, wildlife and visual impacts as well as negative outcomes for residents in terms of quality of life (Walker et al. 2015; Onakpoya et al. 2015; Gibbons, 2015; Heintzelman and Tuttle, 2012; de Lucas et al. 2012). A question has therefore been included in this section to explore the ranking of these types of concerns from most important to least important.

The last section of the survey will deal with demographics. Some important demographic information may include the frequency with which respondents experience turbines (Kontogianni et al. 2014), marital status (Zyadin et al., 2014) age (Ek, 2005) education (Dimitropoulos and Kontoleon, 2009) employment status (Ku and Yoo, 2010) and income (Ladenburg and Dubgaard, 2007). We now turn to the offshore survey.

Offshore wind farm survey

The offshore survey is similarly designed to the onshore survey but contains some key alterations to make it applicable offshore developments. It is 32 pages in length and includes 4 main sections. Similarities are as follows:

- Examines general attitudes towards environmental issues and wind energy.
- Identifies if the respondents are favourable towards onshore wind farm development, offshore wind farm development and the exportation of wind generated energy
- Includes a question to establish the Irish public's current knowledge on wind energy in general.
- Requests information on respondent's local wind farm (be it onshore or offshore) as it was decided that exposure to onshore sites may have a bearing on attitudes to potential offshore sites.
- Requests residential distance of respondent to nearest wind farm and attitudes to construction stage, and ranking feelings about the development from 1 (very negative) to 10 (very positive). See onshore survey description to basis of this method in the literature.
- Questions relating to the respondents willingness to purchase shares and the local and personal benefits which arise from this wind farm.
- Question to determine whether their local wind farm developer cooperated, provided information and financial support to the local community in order to establish "best practice" areas
- Individuals rank how they feel about the development *now*.
- Individuals are asked about their concerns regarding health effects and further demographic questions.

Section C is also the section of the survey that presents respondents with the wind farm choice sets. Stated preference studies allow researchers to assess the demand for environmental protection or ecosystem services through the use of surveys by analysing consumer preferences for a hypothetical situation offering a change in these services. One of the main types of stated preference techniques is choice modelling in which respondents choose between two or more situations with shared attributes of the good in question but with different levels of these attributes (Pascual et al. 2010).

This section establishes that this would be a new offshore wind farm in their area (depending on the survey area) and would be in addition to any wind farms that already exist. The attributes are then introduced to the respondents. The attributes identified include electricity discount, number of turbines, distance from shore, community control and export. There are several key additions to the offshore survey which will now be highlighted.

Previous work has established that those with an interest in "green" issues are more likely to be in favour of wind energy in Sweden (Ek, 2005). It is also likely that preferences about offshore wind farms will be influenced by whether individuals live close to the coast and/or have an interest in marine recreational activities   Included in section D on demographics, respondents are therefore asked to detail the extent of their interaction with marine and coastal spaces. Such questions address the frequency of respondent visits to a coastal areas, types of marine recreational activities engaged in, extent of residential coastal views and the perceived threats of offshore windfarms to marine habitat and stakeholder livelihood.

Survey, sampling method and data collection

Data collection was conducted at the following sites for the onshore wind farm. Derrybrien (Co. Galway) Templederry (Co. Tipperary); Meenadreen (Co. Donegal); Mount Lucas (Co. Offaly); Coomacheo (Co. Cork) and Castledockrell (Co.Wexford)

Data collection was conducted at the following sites for the offshore wind farm survey. Arklow, Co. Wicklow; Dalkey, Co. Dublin; Drogheda, Co. Louth; Dingle peninsula, Co. Kerry; Carna and the Iarras Aithneach Peninsual, Co. Galway; Bunbeg and Derrybeg, Co. Donegal.

Results

We discuss the study findings with respect to focus group research first. This is followed by the survey.

From the 6 public focus groups that were carried out, public perception of several externalities emerged as core barriers to social acceptance of wind farms in Ireland. Regarding onshore wind farms, focus group participants highlighted the following issues of concern:

- Visual impact
- Short setback differences impacting living standards
- Impact on value of houses in the area
- Disruption to traffic routes and community access during construction
- Construction noise disturbing the community
- Continued expansion of such developments beyond reasonable levels
- A loss of control or say in factors effecting the community
- Damage to environmentally sensitive land or land still useful to the community (peat/bog)
- Irregular power supply given uncertain wind conditions

- Noise pollution
- Light Impact / Flicker
- Poor management regarding the planning process (lack of trust of community as a result)
- Habitat impact such as birds (e.g. hen harriers)
- Effect on TV coverage and reception
- Subsidisation of wind farms increases electricity costs
- Fears about radiation and health impact
- Lack of say or information about the development and its continued management

Respondents were broadly aware of environmental benefits. Sentiments indicated public view wind farm developments as potentially financially beneficial to the local community in terms of personal electricity costs, development schemes and employment creation. Negative perceptions included disturbance to road and businesses during construction, short lived employment opportunities, and visual/health impacts, property devaluation and equity issues. Focus groups tended to vary in terms of preferences for either community benefit schemes and electricity reduction costs as compensation for wind farms development. There was a general lack of awareness of the extent of potential economic benefit which a single turbine provided to a community. Regarding ownership models, there was a general lack of trust across all groups regarding planning process and private non-Irish entities. While this lack of trust extended to semi-state bodies, there was a preference for this ownership model as group members generally felt they had more lobbying power and that semi-state bodies offered more accountability, offering the community more "control in the future". Private-public ownership was also preferred. Respondents were wary of the export of electricity from wind farms due to the possibility of excessive development arising, purely for the supply of foreign electricity demand. Preference for Irish electricity needs being met, or where export arose, significant benefits coming back to the community for bearing the burden of turbines. Regarding information, group members generally placed a high priority on this as without it, the general feeling was a sense of powerlessness about any development and what the potential impacts were. Suggestions for information dissemination were a independent state agency, community representation and improved interaction with multiple professionals involved in a development (e.g. engineers, scientists, etc.).

Regarding offshore wind farms, focus group participants highlighted the following issues of concern:

- Impact on views of ocean and coastal areas
- Impact on value of houses in the area
- Disruption to traffic routes and community access during construction
- Underwater drilling impact on marine life and habitat
- Impact on fishing community livelihoods
- Short-lived economics benefits (construction period)
- Attractive to a point; but unattractive if the scale of them increases
- Can't store the energy and it is irregular in nature so there are issues with supply consistency
- Not enough consideration being given to alternatives such as wave and tidal energy
- Fears about radiation and health impact

- Lack of say or information about the development and its continued management

For offshore focus groups regarding benefits, drawbacks, compensation, export and information, the overall attitudes of offshore focus group members reflected those of members from the onshore groups. However notable differences were a strong preference for turbines to be several kilometres from shore. Respondents felt that slight sight of turbines was generally tolerable but close to shore was generally deemed highly undesirable.

By covering a multitude of topics raised in the focus groups by participants, it was possible to narrow the issues of primary concern down to a smaller number of wind farm attributes that represented externalities that acted as the main barriers to social acceptance of wind farms. One of the ways this was done (in addition to discussion and observation of opinions) was through a group decision exercise. In this exercise, participants worked together to adjust the levels of various wind farm attributes such as number of turbines, height of turbines, environmental impacts and management structures. Several beneficial attributes were also included in the exercise, as had emerged from focus group discussions. Examples of these were information provision, electricity discounts, community benefits etc. Through this exercise it was possible to identify which externalities were of more concern to the participants and which were less of an issue. It was also possible to identify what type of policy or management responses better alleviated such concerns or externality issues.

For the onshore focus groups, the key externalities to emerge were turbine height, setback distance and the number of turbines. The opportunity to have more control over the decision making process and the potential for an electricity discount emerged as alleviating management responses to focus group members concerns. For the offshore focus groups the outcome looked similar, but the bigger issue became the distance of the wind farm from shore and the number of turbines, while turbine height became less critical. Participants also seemed very concerned around the issue of export, primarily believing that wind energy generated in Ireland should be used by Irish electricity customers. Environmental concerns, while these arose in the discussions during the focus groups, did not take precedence over those just discussed when it came to the group exercise and participants had to make decisions about which wind farm attributes were the primary ones they wished to adjust to meet their preferences.

Developer focus group

One of the goals of this project has been to identify ways in which developers have adapted to improve consultation, forge trust or partner with communities in shared ownership of WFs. This document briefly describes the verbal accounts of developers during the focus groups and first PMC meeting that highlight some of these adaptations.

A key theme that emerged during developer discussions was that of information. Questions such as: “are the community aware of the true benefit?” and “are people fully informed?” arose. It was highlighted during discussions that whether a community is for or against WF developments largely hinges on the quality of information they receive. Quality information, it emerged, is determined by three things: firstly, that it is relevant, factual and evidence based; secondly, that the community has trust in the person or organisation supplying that information; and thirdly, that there exists a suitable forum for this information to be openly provided without the process being used as a political spectacle. A major challenge according to developers has been getting truthful information to communities about costs and benefits of WFs, without anti-WF campaigners usurping such informative events and making serious claims about the negative impacts of WFs on health and the environment which have no basis in evidence.

According to developers, in the early days, it was typical to arrange a public meeting in a local community hall building to provide information. Developers gave examples of individuals with anti-WF views attending meetings and interrupting proceedings, making false or unsubstantiated claims and generally hi-jacking the fair and open delivery of information to the community. Developers highlighted the fact that people in the community with a moderate viewpoint on WFs may have become intimidated by such claims and the intensity of the anti-WF protestors.

The primary adaptation developers have put in place as a response to this situation is to organise instead, multiple private meetings with members of the community. Through dissemination of leaflets, information about potential developments, how roads may be affected and other general information, developers felt that it allowed them to build a personal relationship with community members so that more trust was placed in the information they were providing. One developer claimed that "people don't want to hear from a representative; they prefer to talk to an engineer or one of the employees actually working on the project who can tell them exactly what's happening on the ground". This view was not echoed by all developers in the focus group with some of the more large scale developers suggesting good results are obtained by having a project representative whose sole role was to interact with the communities near development sites. The key thread to the approach being used by developers however, in adapting to the problems posed by publicly held forums, was the use of private meetings with community members to build a critical mass of individuals that were fully informed about the costs and benefits of a WF development.

An interesting dimension to this, as put forward by the developers, was that developer bid projects were more suited to multiple private meetings, so therefore were less prone to misinformation and distortion than purely community projects that did not involve developers. The failure of a community WF in Waterford was put forward as an example of this. It was argued that instead of the extensive public consultation and engagement of the Waterford based development helping the project proceed, it actually undermined and ultimately prevented the going ahead of the project because of the extent of objection that arose.

Critically, developers also argued that in an atmosphere of reasonable discussion, it was more possible to accommodate the issues and objections of community members with reasonable and fair concerns.

Joint focus group

The joint focus group involved developer representatives and public representatives hereafter referred to as developer respondent or public respondent. The first topic discussed in the joint focus group aimed to establish the perspectives held by participants on public attitudes towards wind farm development. One developer respondent involved in a community wind farm (WF) believed that although public attitudes were positive in the past, this had changed in recent times, with the voices of more extreme anti-wind farm organisations playing a part in this. It was also proposed that certain high profile large scale developments failed to take into account of public opinion.

A public respondent proposed that many members of the public are ignorant when it comes to WF development, and that this can result in NIMBYism. Other public respondents agreed that the industry required “good PR”. It was stated that many citizens are unaware of issues, such as the need for renewable energy.

A developer respondent agreed that a surplus of misinformation exists in the industry and held the view that developers are not adept at correcting this or engaging with the public. This vacuum could lead to unchallenged information emerging. The provision of information was seen as crucial in terms of trust building for many public respondents, with the suggestion among them that a lack of information could lead to apprehension and fear among local residents living near a WF. When probed on the forms this information should take public respondents suggested public meetings, local advertisements and brochures as a starting point as well as experience related information such as visits to actual WF developments. It was also suggested by them that the promotion of renewable energy from agencies such as SEAI should extend to education in schools.

Public respondents conveyed the view that many members of the public would be suspicious about the motives relating to WF development, primarily relating to the provision and distribution of benefits. When probed on personal experience of benefits, many public respondents cited employment, sports clubs and local spending during construction although others pointed out that this was a temporary benefit. It was suggested by several public respondents that discounted electricity would be the most appropriate form of benefit, although the developer representative advised that it would need to be mandated.

On the subject of community interaction, a developer respondent proposed a stakeholder forum with local representatives acting as the project steering group. These representatives would be informed and disseminate this information throughout their community. Other community participants agreed that this forum was an interesting idea, and suggested that grant schemes could be provided to fund it. Developer respondents agreed that town-hall meetings were problematic and uninformative, with frequent disruptions from dissenting voices.

When probed on particular issues that arose in relation to their local wind farm development, the public respondents cited disruption during the construction phase of a WF, noise and visual impact once it has been established as the main issues. It was felt however, by public respondents that these concerns were not felt by all equally in the community, and the fair distribution of benefits should compensate for this.

A developer respondent highlighted the lack of regulation regarding WF currently in Ireland. This, it was suggested, has led to a negative reputation for the industry. It was proposed that regulation was required to inform the industry of exactly what was needed of them in terms of minimum contributions regarding benefit arrangements and collaborations and consultations with the community.

On the topic of potential barriers to wind farm development in Ireland, community respondents suggested logistical issues relating to the selection and access to appropriate land. A developer respondent suggested that the promotion of small scale, community owed turbines could be a solution to development issues. The developer respondent continued in this vein by recommending that the large tracts of land owned by semi state bodies should be opened up to community development. If this was to occur, then Ireland could increase the number of turbines being built and look to exporting wind energy. Although public respondents suggested the cost of storage as a barrier to exportation, the developer respondent saw this as an opportunity. If the energy can't be stored, it should be exported. Though strong policy was suggested as a requirement, it was highlighted by the developer representative that if there is no regulation on smaller domestic development, large exportation projects would be problematic.

Public respondents put the ownership of this duty of regulation on the government, suggesting that currently the majority of the profits of development go overseas. If the government were to intervene and propose regulation then perhaps more profit would remain in Ireland. The developer respondent also suggested that top-down advocacy was required from politicians.

The topic of ownership was largely dominated by the concept of community wind farms, with many public respondents questioning the developer representative involved in community WF on several issues, including local benefits, wind farm size, profitability, planning and logistics. The developer respondent also highlighted his own issues getting the project up and running, including funding issues, grid access and planning. It was also suggested that neither large scale developers nor anti-wind farm activists are interested in community ownership.

Other ownership types suggested by a developer respondent included a hybrid model, whereby the developer takes the financial risk and collaborates with community members who wish to purchase shares. It was proposed that investing in the wind farm for long term gain was better than handing out short term benefits. The developer respondent continued by suggesting that there were issues relating to community owned developments including financial and organisational difficulties. This hybrid model would provide the experience and finance of developers to the community for their benefit.

The respondents however argued that public benefit schemes were still required due to the environmental and visual impact of development. It was suggested that electricity bills could be used as a contribution to the local wind farm, with half of local's monthly bill being paid towards the development as their investment.

Private wind farm developers were viewed as "outsiders" by many community participants as well as the developer respondent involved in a community WF, with suspicion over their motives and the provision of local benefits.

It was agreed by many participants that a semi state structure, with 50% local ownership, 50% state owned would be an appropriate development structure, easing the burden on local residents and providing trustworthy leadership.

Many public respondents viewed offshore development as more positive than onshore, with reduced visual impact as the primary benefit. However, many barriers were defined by both public and developer respondents including cost and control issues, with the conclusion that if the projects were owed by the state many of these issues may be avoided.

Survey results: Descriptive statistics

A summary of general attitudes to wind energy and my local experience

The figure below indicates general attitudes towards wind energy. The majority of respondents were found to be generally in favour of wind energy with individuals strongly in favour conveying a preference for offshore wind turbines. Respondents show less support for wind farms developed for export.

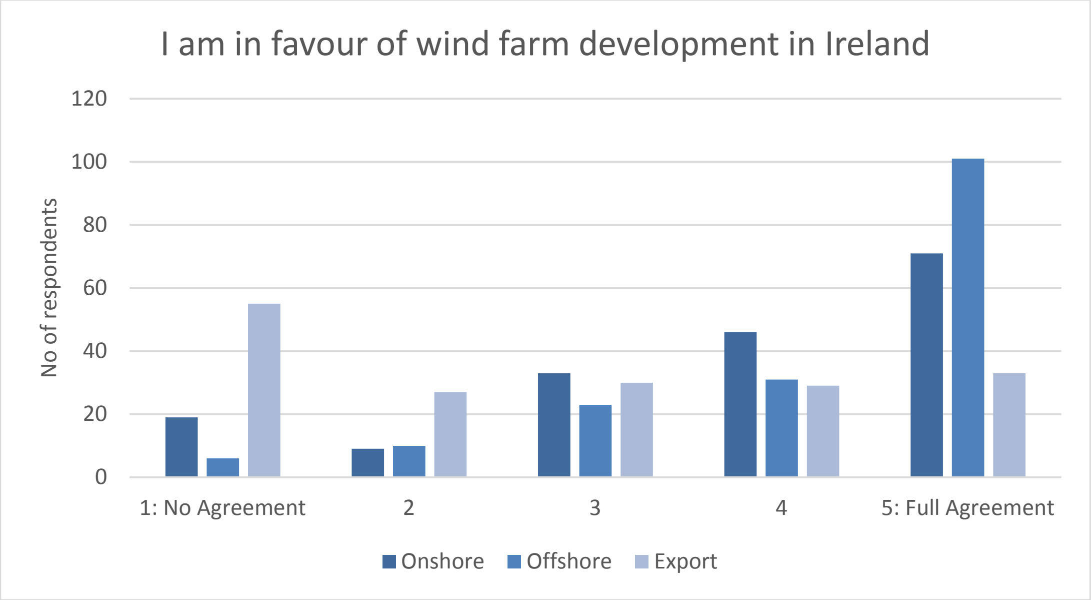

Figure: Opinions about the number of wind farms in Ireland with respect to onshore wind farms, offshore wind farms and wind farms dedicated to export.

Respondents were asked if their opinions had changed over time regarding their local wind farm. The general trend (see figure below) is one of no change, although respondents who were very positive about their local wind farm became more positive through time.

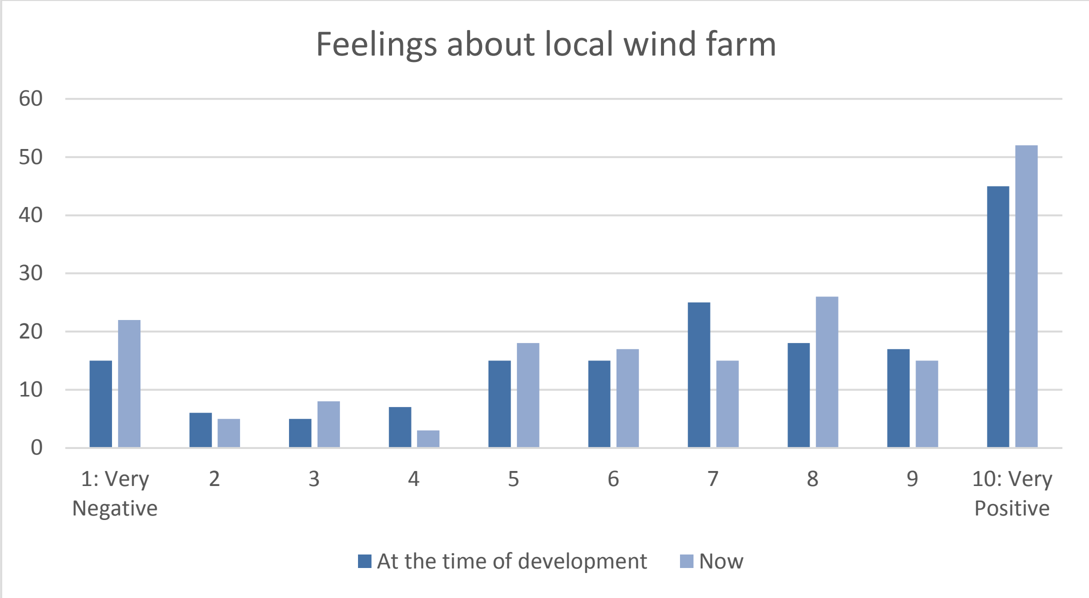

Figure: Feelings about local wind farm over time

Respondents were asked whether the local wind farm developer cooperates, provides financial benefits or information to local residents. Most respondents (figure below) are either neutral or appear to strongly agree that developers do engage with local residents with respect to these issues.

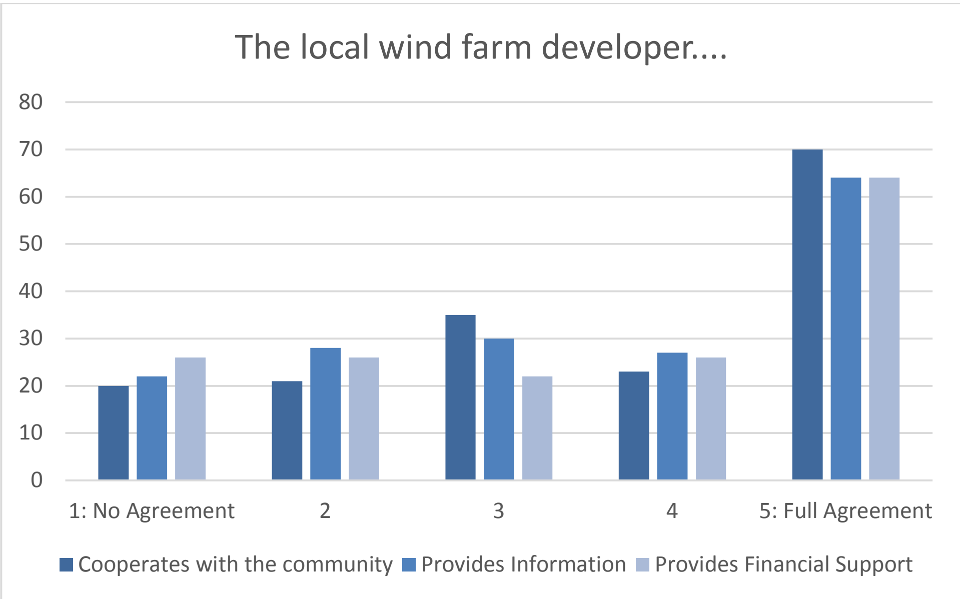

Figure: The local wind farm developer cooperates with the community

Respondents were also asked whether the experience that have had with a local wind farm developer made them feel less positive or more positive about future wind farm development in Ireland. The figure below suggest most respondents either had not changed their position or they were more positive.

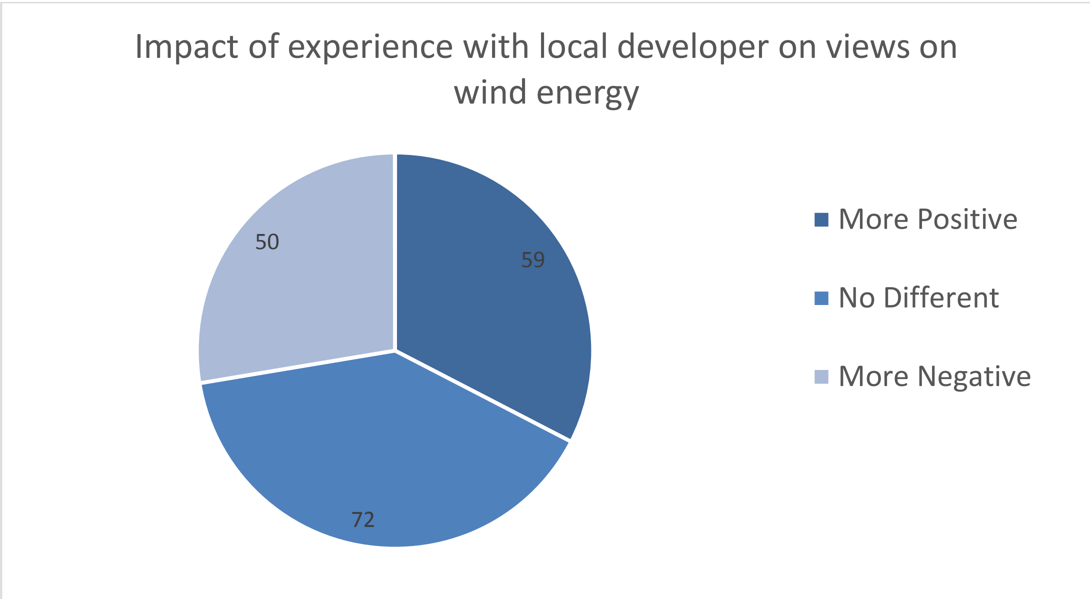

Figure: Impact of experience with local developer on views on wind energy

With respect to ownership respondents held a preference for Irish farmers local to the area and semi state companies (figure below). Local community ownership and private (Irish) developers being the least preferred.

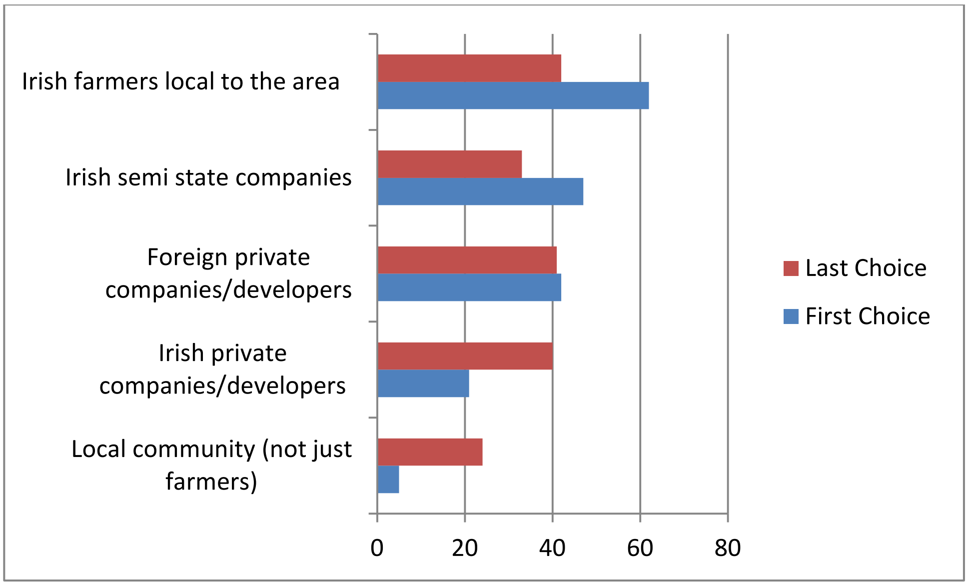

Figure: Preferred ownership type

Section C Valuation of externalities and analysis of Status Quo Respondents:

All models were estimated using NLogit 5. The status quo option was selected by 35% of those surveyed, regardless of the combination of attributes offered. One of the key axioms associated with decision making in choice experiments is that of continuity, which assumes unlimited substitutability between attributes. Individuals are assumed to take account and make trade-offs between all the attributes presented in the choice set. Discontinuous preferences can result in lexicographic ordering and can restrict the estimation of the marginal rate of substitution between attributes (Campbell et al. 2008). It is possible that some of these respondents represent "genuine zero bids" and these individuals are not WTA a wind farm because they do not value it in a utility sense. This does not mean, however, that a respondent is not WTA any form of wind farm. While the respondent states their hypothetical unwillingness to accept compensation, it is possible that this is not the case in "reality". Those who report zero bids are often grouped together with protest responders (those who place a zero bid for reasons other than having a zero value) and those who select the status quo because don't know their value; and are removed, leaving the analysis restricted to those WTA some form of compensation. Alternatively genuine zero bid respondents can be included with those WTA compensation.

In order to establish the motive of the SQ respondents, all respondents were asked follow up questions. The figure below outlines the underlying motivations for these responses:

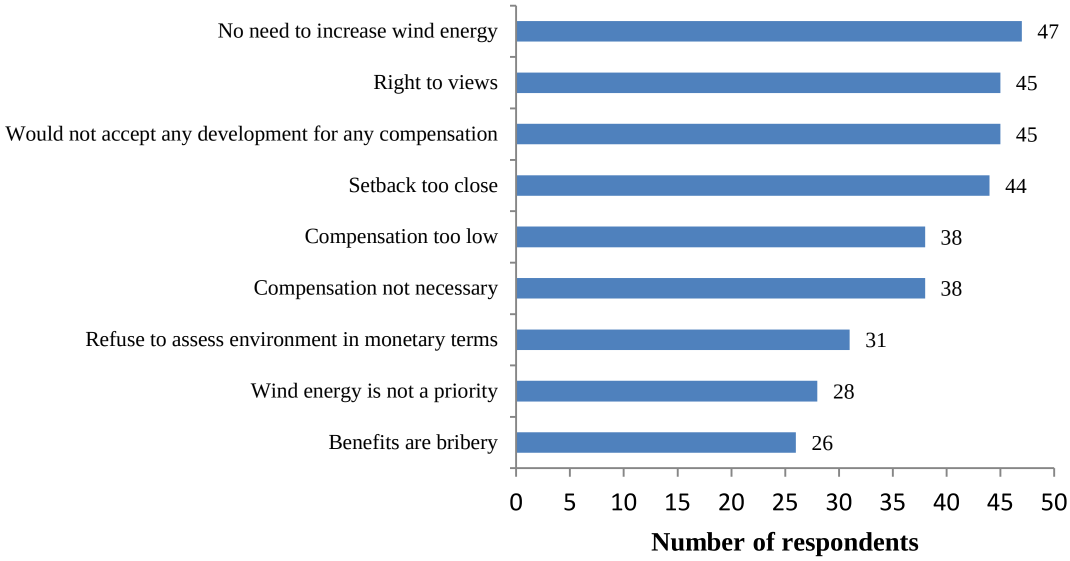

Figure: Reasons for selecting the status quo

The majority of SQ respondents strongly agree that the current level of wind farm development in their area is sufficient and there is no need to increase it. 45 respondents agree that it is their right to enjoy uninterrupted views, and they are not willing to accept any amount in compensation for a loss of this enjoyment. 45 out of the 64 SQ respondents would refuse to accept a new wind farm in their area no matter what amount of compensation they were offered. Although some of these responses may be classified as “protest” responses, in this case all are included in the final analysis.

In order to establish if SQ respondents experienced different wind farm development to the non-SQ respondents, the survey included questions on their local wind farms.

The figure below highlights the percentage of SQ and non-SQ respondents who feel that the behaviour of their local wind farm made them feel more positive, no different or more negative about wind energy in general:

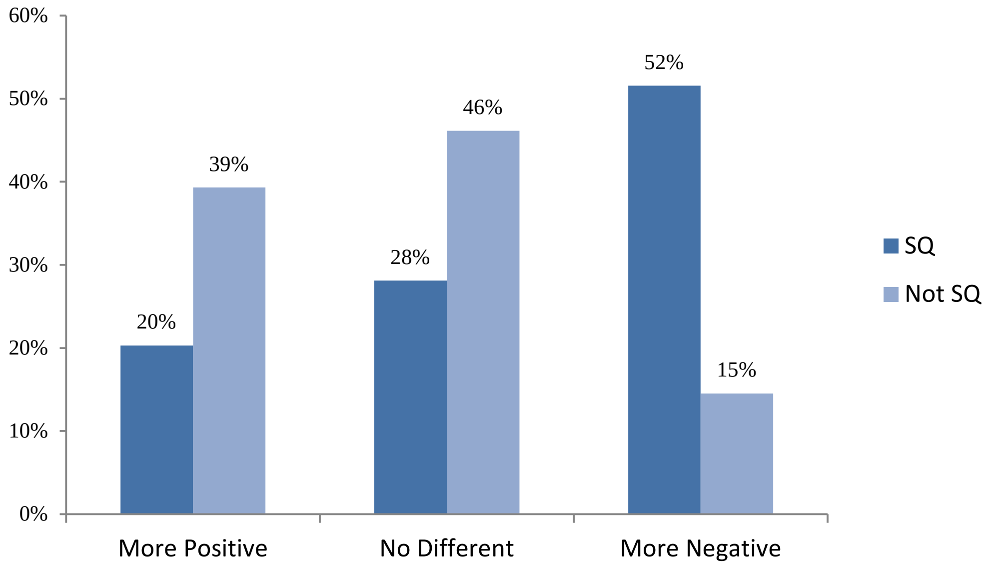

Figure: Experience with local developer

As evident, the SQ respondents feel much more negative about wind energy as a result of the local wind farm developers actions than their non-SQ counterpart.

To elaborate further on this issue, the survey included questions on the provision of financial benefits, information and cooperation from developers with the local community.

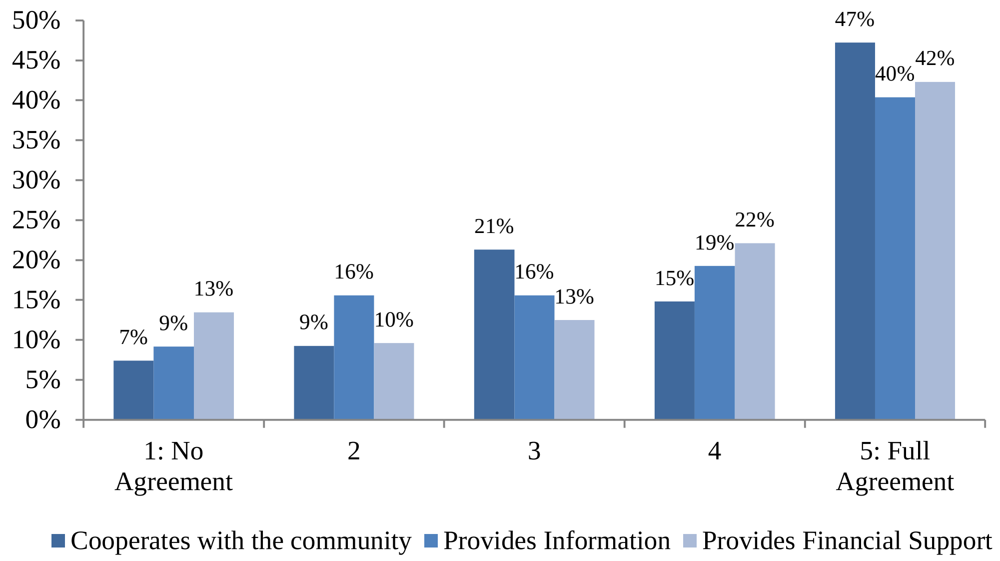

Figure: Non-SQ respondents feelings about local wind farm developer

The majority of the non-SQ respondents agree that the developer engaged with the local community on these 3 key points, with fewer than 14% disagreeing totally (figure above).

In comparison (figure below), fewer SQ respondents were in full agreement and the percentage of those who totally disagree that the wind farm developer cooperated, provided information and financial support is higher for this cohort. This indicates that the respondents experience and perception of the provision of benefits and information from developers in these areas has a strong influence on the willingness to accept future development.

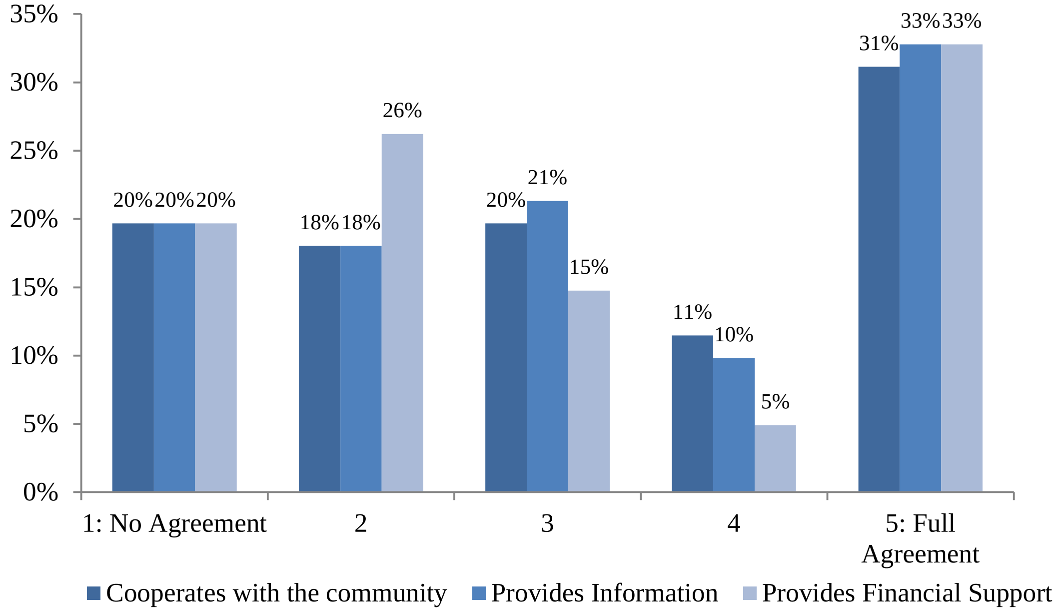

Figure: SQ respondents feelings about local wind farm developer

Model Output:

The Table below provides the results of 2 models, a multinomial logit model (MNL), a random parameters logit model (RPL).

As previously outlined, the MNL model assumes the Independence of Irrelevant Alternatives (IIA). This assumption was tested using the Hausman test in Nlogit. This is a two-stage test; the first stage estimates an unrestricted model with all alternatives and then a model with restricted alternatives is estimated. The test statistic is:

$$q = [b_u - b_r]' \ [V_r - V_u]^{-1}[b_u - b_r]$$

where b_u is a column vector of parameter estimates for the unrestricted model, b_r is a column vector of parameter estimates for the restricted model, V_r is the variance-covariance matrix for the restricted model and V_u is the variance-covariance matrix for the unrestricted model (Hensher et al. 2005).

The results from these tests (estimating 3 restricted models, one for each choice set option) resulted in *p*-values of 0.00 for each. Comparing the *p*-values for the tests for option A and C to alpha equal to 0.05, we reject the IIA assumption for the model. This suggests that the MNL model may not be the most appropriate for this analysis and that a less restrictive model, such as the RPL must be considered (Hensher et al. 2005).

The coefficients outlined in the RPL models indicate the means of the random parameter distributions with the standard deviations shown to the right of columns 3 of the table. All parameters apart from COMP are characterised as random parameters with normal distributions. COMP is assumed to be non-random and so the standard deviation is not estimated. With regards to the other parameters, it is possible that the assumption of normality is not appropriate and that other distributions would provide a better fit. Triangular and uniform distributions were tested and the resulting log-likelihood values were not statistically significantly different to those of the normally distributed model.

The significance of the standard deviations for all attributes except SETBACK 1000M indicates the existence of unobserved preference heterogeneity for these coefficients under the model assumptions and that these parameters do vary across individuals and choice decisions. The RPL model therefore provides a better fit.

The RPL model has a lower Akaike information criterion[2] (AIC), improved log-likelihood function[3] and improved pseudo R-squared[4] values which indicates the superiority of the RPL model over the MNL.

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[2] The AIC is a measure of the relative quality of models for a given set of data. In general, a lower number implies a better fit

Table: Parameter estimates, standard errors within parenthesis:

Attributes and interactions	MNL Coeff (s.e)	RPL Coeff (s.e)	Std dev
TURBINES	-.00402	-.00709*	.02664***
	(.00246)	(.00390)	(.00457)
EXPORT MEDIUM	-.05244	-.03004	.30633*
	(.07578)	(.10186)	(.16950)
EXPORT HIGH	-.21694***	-.36500***	.30633*
	(.07833)	(.10212)	(.16950)
SETBACK 1000M	.43299***	.60923***	.33038
	(.08293)	(.11015)	(.20434)
SETBACK 1500M	.48000***	.82186***	1.00057***
	(.08785)	(.15380)	(.14653)
CITIZEN MEDIUM	.26280***	.37745***	.37887**
	(.07601)	(.09848)	(.15926)
CITIZEN HIGH	.12873	.25568**	.52635***
	(.08000)	(.11147)	(.15358)
COMP	.00118***	.00180***	
	(.00018)	(.00025)	

[3] The log-likelihood cannot be used alone as a goodness of fit because it is a function of sample size. However, it can be used as a comparison for the fit of different coefficients. As the log-likelihood is maximised, the higher value is better.

[4] McFaddens pseudo R^2 treats the log likelihood of the intercept model as a total sum of squares and the log likelihood of the full model is treated as the error sum of squares. Though the pseudo R^2 is not the exact same at the R^2 of a linear regression, there is a relationship between the two (Domencich and McFadden, 1975). A pseudo R^2 of 0.30 represents a "good" model fit for a discrete choice model. Pseudo R^2 values between 0.30 and 0.40 are equivalent to an R^2 between 0.60 and 0.8 in a linear model (Henscher et al, 2005).

ASC	1.10847***	.32688	6.23007***
	(.12025)	(.76023)	(.78820)
Log- Likelihood	-2282.932	-1467.070	
McFadden Pseudo R^2	0.021	0.38	
A.I.C	2.129	1.378	
No. of respondents	181	181	
No. of observations	2172	2172	
No. of Halton draws		1000	

Notes: Level of significance, ***=p<1%, **=p<5%, *=p<10%

The sign on the coefficient TURBINES is negative across all models indicating the reduced utility for each additional turbine for respondents in the sample, however this is insignificant in the MNL model and only significant at 10% in the RPL.

In both models turbine EXPORT is specified as a dummy variable and indicates a movement from a base of no exporting wind farms, to 50:50 domestic & export (medium) and 100% export (high) respectively. This is negative for both dummy variables indicating a loss in utility from moving from no export to exporting wind energy. However the medium level of exportation is not significant in either model, but the high level is negative and significant at 1% in both models.

The variable SETBACK is also represented as a dummy variable representing a greater distance between the respondents' home and the wind farm. The base distance is 500m between the wind farm and a households' residence. The attribute SETBACK 1000M and SETBACK 1500M therefore implies the hypothetical wind farm moving 500m and 1000m further away from the resident respectively. In all instances results from the MNL model and both RPL models reveal a significant positive coefficient on the setback attributes. This implies that respondents' gain positive utility if the hypothetical wind farm were to be moved further away from their residence.

The variable CITIZEN is also a dummy variable, representing greater information provision and engagement. The base is the legal minimum provision of information. The sign on the medium level of CITIZEN engagement is positive and highly significant in both models, highlighting the utility gained from increased information. While the sign on the high level is positive, it is not significant in the MNL but is significant at 5% in the RPL model.

The coefficient on the compensation variable is also positive and highly significant in both models. This is as expected in a WTA estimation, given the way the DCE was framed. This implies that respondents' gain positive utility from greater amounts of compensation.

The alternative specific constant (ASC) representing the status quo option is positive and significant in the MNL but insignificant in the better fitting RPL model.

Welfare Estimates:

The Table below indicates the marginal willingness to accept (WTA) amounts for both models. The estimated WTA for the turbines and exporting attributes are positive. Respondents would require between €3.40 and €3.93 per annum in compensation for each additional turbine included in the wind farm, a fairly stable result amongst the two models. The table below shows that respondents would only not require compensation for a 50:50 domestic exporting wind farm, with a negative WTA of between €16.65 and €44.33, however this is not statistically significant. To accept a wind farm that exports 100% of its energy, respondents require between €183 and €202 per annum.

In contrast the parameter estimates for the setback coefficients are negative. As one might expect this suggests that as setback distances between the wind farm and private residences are increased the required WTA in compensation falls. For example the attribute SETBACK 1000M indicates that if the distance were increased from 500m to 1000m the respondent would require between €338 and €366 less in compensation per annum (in the form of a discount to their electricity utility bill). As one moves further away from the turbines it is reasonable to expect the respondent to accept lower levels of compensation, as is the case in both models. The introduction of CITIZEN engagement leads to a decline in the amount of compensation required for a given respondent, the reduction in compensation is for the medium level of engagement is between €544 and €579, but is lower and statistically insignificant for the greater level of engagement.

Table: Marginal WTA estimates, standard errors within parenthesis:

	MNL € /H.H,P.A	RPL € /H.H,P.A
TURBINES	3.40* (1.94	3.93* (2.01)
EXPORT MEDIUM	-44.33 (64.37)	-16.65 (56.62)
EXPORT HIGH	183.40** (71.80)	202.28*** (59.77)
SETBACK 1000M	-366.05*** (78.92)	-337.63*** (62.78)

SETBACK 1500M	-405.79***	-455.47***
	(77.34)	(78.82)
CITIZEN MEDIUM	-222.18***	-209.18***
	(72.70)	(61.15)
CITIZEN HIGH	-108.83	-141.70**
	(69.60)	(63.45)
Log- Likelihood	-2282.932	-1467.070
McFadden Pseudo R^2	0.021	0.38
No. of respondents	2.129	1.378
No. of observations	181	181
No. of Halton draws	2172	2172

Notes: Level of significance, ***=p<1%, **=p<5%, *=p<10%

Policy Simulations:

In the table below we convey the findings by simulating WTA for 6 wind farm policy scenarios, and arrange it so that wind farm size is fixed at the mid-size level of 20 turbines per farm and the wind farm is presumed for domestic use. These two variables are fixed in order to analyse the impact of a change in two attributes: setback distance and the medium level of citizen engagement. The table presents the WTA estimates and standard errors associated with 6 scenarios for the RPL model. In case 1, a “worst case” scenario given the results, the wind farm is simulated at 500m from residents and engagement is not provided. This scenario results in a compensation requirement of €78.55 per person per annum (p.p, p.a). In the second scenario, a citizen engagement is included but otherwise all attributes remain the same. In this case, there is a welfare change amounting to €209.18 (€78.55+€130.63) p.p, p.a. in the form of a reduction in required compensation. Moving right across the table from case 1 each scenario prior to case 5 provides an improvement in utility on the previous case. This indicates that reductions in WTA values can be achieved either by increasing setback distance or including community engagement (where engagement was not previously present). Notably case 4 results in a higher utility level than case 5. Increasing setback distance to 1500m and not including engagement in case 5 results in a utility loss of €91.34 p.p, p.a. in comparison to a scenario with a setback distance of 1000m and inclusion of citizen engagement.

Table: Policy simulations (standard errors within parenthesis).

Attribute	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
SETBACK	500m	500m	1000m	1000m	1500m	1500m
CITIZEN ENGAGEMENT	No	Yes	No	Yes	No	Yes
WTA	78.55* (40.20)	-130.63* (75.76)	-259.08*** (71.92)	-468.26*** (106.07)	-376.92*** (86.02)	-586.10*** (115.83)
CONF INTERVALS	-0.23	-279.12	-400.05	-676.16	-545.51	-813.12
	157.34	17.87	-118.11	-260.36	-208.32	-359.08

Notes: Level of significance, ***=p<1%, **=p<5%, *=p<10%

The standard errors (within parenthesis) were calculated using the WALD command in Nlogit and values were obtained using the Krinsky and Robb method with 1000 draws.

Using the estimates reported above by way of example we calculate the effect of increased setback distance and the inclusion of a engagement separately over the lifetime of a wind farm. Assuming 100 residents are affected by a 20 year wind farm development and holding turbines and height as depicted above; a total compensation payment of €157,100 (case 1) is required for a 500m setback distance when no engagement is present. If engagement is included at the same setback distance, this results in a negative compensation amount of €261,260 (case 2): in effect a net benefit (although this is only significant at 10%). Looking to case 4, which is statistically significant at 1%, the net benefit amounts to €936,520. These amounts rise for wind farms greater than 20 turbines and with higher numbers of impacted residents.

These results suggest that greater setback distances alone may not result in the highest utility for residents. By increasing setback distances to 1500m and including engagement the largest welfare gains can be achieved. However, case 2 and case 4 provide interesting scenarios from a policy perspective. Case 2 might be more suitable for less densely populated communities. The provision of engagement even at close setback distances results in a net benefit. This could aid in internalising the externalities of wind farm development yet it constitutes an inexpensive solution to the issue of community acceptance for developers. Case 4 may represent the most suitable compromise between residents and wind farm developers in regions with a greater number of impacted residents. Residents benefit from increased setback distances (reduced noise, reduced visual impact etc.) over the longer term as well as the short term gains of improved information provision and interaction with a developer. For developers, case 4 may present a more attractive result than case 6. Increasing setback distances to 1500m would greatly restrict future development due to Ireland’s one off housing policy. Depending on the number of affected residents, the provision of citizen engagement could offer a lower cost solution for developers. The inclusion of engagement with minimum setback distances established at 1000m could provide significant welfare gains to moderately densely populated communities in development areas and prevent strict restrictions on the land available for wind farm construction.

Conclusions

Overall we demonstrate that the majority of respondents are willing to make (monetary) trade-offs to allow for wind power initiatives provided that local residents are offered private compensation (discounted utility bill) or are better engaged, consulted and informed by developers in the wind farm development process. We estimated that a given respondent requires between €544 and €579, in annual compensation if provision is made for citizen engagement.

With respect to willingness to accept, the DCE used in this study produces what appear to be reasonable results. Willingness to accept is price sensitive and all attributes have a significant impact on the choice of the wind farm. Respondents prefer wind farms located further away from their homes. Respondents exhibit a strong preference for engagement and the provision of information and dialogue between residents and the developer about the wind farm project.

The negative parameter estimates for setback distance indicate that respondents prefer turbines that are further away from residential dwellings and this is consistent with the literature (Fimereli, et al., 2008; Meyerhoff, et al., 2010; Meyerhoff, 2013; Vecchiato, 2014; Mariel et al., 2015). However, respondents are willing to make (monetary) tradeoffs to allow for setback distances to be changed. For example the RPL model with interactions reveals that if the distance were increased from 500m to 1000m the respondent would require €337.63 less in compensation per annum (in the form of a discount to their electricity utility bill). Our findings are consistent with the study by Meyerhoff et al. (2010) who find that median willingness to pay decreases with increasing distance between the wind turbines and residential areas.

In this regard, our results suggest that a policy focussed on consultation and engagement combined with moderate increases in setback distance could be an effective instrument to enhance local acceptance of wind farms by developers. This has implications for the placement of wind farms. Increasing minimum setback distances in Ireland could restrict the capacity for future onshore wind farm development and make it more difficult to meet future renewable energy targets compared with a policy of compensation. Instead we recommend that as part of the evolving policy process including the forthcoming RESS initiatives high priority needs to be given to the process of consultation with local potential stakeholders.

Our findings on developer adaptation do indeed appear to suggest that developers may have changed the way they engage with communities. The main change seems to be a move from open style public meetings to individual face-to-face consultation with affected households.

The close interaction between local authorities and developers with the local community is important for local acceptance as is the quality of information and compensation available to the local community impacted by the project. For example our findings indicate that when respondents were asked whether the experience that have had with a local wind farm developer made them feel less positive or more positive about future wind farm development in Ireland. The findings suggest most respondents either had not changed their position or they were more positive about the development.

Focus group findings suggest respondents find information provision and local consultation very valuable. Consideration should be given to the role of a community representative as part of the process of engagement. Support for a wind farm could be built by providing trusted community members with sufficient information to consider supporting the initiative and explaining it to the community. This may include site visits to an operating wind farm and their respective communities by these local advocates and technical staff concerned with the wind farm to deal with concerns over noise and other issues. Smith and McDonough (2001) emphasise the importance of open and transparent decision making to build- trust in the developer and in the planning process.

Project Management

The report focusses on the main activities including the survey and the focus groups. The focus groups and web site have been completed and updates to the Blog are on-going as part of the dissemination process. Unfortunately, the survey and data collection has not been finalised and both surveys have yet to be completed. Data collection has been delayed for a number of reasons. Preparation of the offshore survey was delayed due to staff illness and data collection of both surveys was severely disrupted by weather conditions in the field. However, a summary of preliminary findings to date is given above regarding analysis and reporting of the onshore survey based on 191 respondents.

Project title: An economic analysis of wind farm externalities and public preferences for renewable energy in Ireland”

Energy Research, Development and Demonstration Programme 2017 (RDD/00137)

Project Co-ordinator: Tom van Rensburg

Signature:

Date: 28/03/18

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