Are Smaller Turbines the Way Forward for Wind Energy in Herefordshire?

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Abstract

This study set out to determine the social and economic viability of a proposal that smaller turbines are 'better' for wind energy in the county of Herefordshire. The study is in two parts, an opinion poll and a technical desk study. The opinion poll was to discover variations in attitude to three sizes of turbines. Data gathered to allow sample verification also allowed investigation of how attitude varied with demographic factors. Additional questions gave estimates of public perception of WECS effectiveness related to size; and some basic findings on issues of ownership and investment.

A random stratified sample of 500 county residents yielded results showing strong correlation between size and attitudes. Questions were designed to also test the 'conditional' supporter model proposed by Bell and others, which was confirmed. Older and better off groups are significantly more likely to be opposed to any size of WECS; but strongest support also includes younger better off people. Respondents over estimated output of smallest and under estimated output of largest turbines. A considerable sub population supports the technology and local ownership, appearing willing to invest. Some methodological issues remain unresolved, but the results given are considered sufficiently robust for this scale of study.

The economic analysis was heavily dependant on a few meta-studies, backed up with calculations from primary data for calibration. The proposal to develop arrays of small turbines in place of large machines is revealed as unviable in energy and financial terms. A model of sub urban or industrial locations for medium and large scale WECS is proposed. In addition a community ownership model for projects at this scale is advanced as a pathway to local energy resilience, supportive participation, and energy equity.

Acknowledgements

I would like to thank, in no particular order my Supervisor Dr. Ruth Stevenson for insight, clarity, and unwavering patience; all the staff of CAT/GSE; Chickenshack Co-op, Christine and Rick, and the Thomas family for shelter and spaces to study; and the five hundred.

Dedication

to Rachel, for showing the way.

Contents

Glossary and abbreviations used

AONB: Area of Outstanding Natural Beauty. Statutory protected landscape area with special restrictions on development.

BBNP: Brecon Beacons National Park. Statutory protected landscape area with severe constraints on development, including contextual considerations in adjoining areas such as Herefordshire.

BWEA: British Wind Energy Association. UK Wind Industry advocacy and lobbying group, now called RenewableUK.

CF: Capacity Factor. Term used to quantify real vs theoretical maximum output of a generator system. Defined as actual annual output in kWhs divided by rated capacity times hours in year. It is dimensionless and often expressed as a percentage.

CPRE: Council for the Protection of Rural England. Landscape lobbying group.

DECC: Department of Energy and Climate Change

DTI: Department for Trade and Industry

ENSG: Energy Networks Strategy Group, Industry expert panel reporting to DECC on medium to long term grid strategy.

EROEI: Energy Return on Energy Invested. The ratio of total energy produced over the life of a project divided by the total primary energy consumed by it.

EST: Energy Saving Trust. UK quango to promote reduction in energy demand through encouraging individual, business and community action.

FiTs: Feed in Tariffs. A support regime designed to encourage deployment of renewable energy systems by guaranteeing a price for all electricity produced over a specified period. The actual value per kWh depends on the plant size, type and expected project lifetime.

GDPO: General Permitted Development Order. Statutory instrument defining development activities not requiring planning permission.

GW: Gigawatt, a thousand million Watts (qv)

HCC: Herefordshire County Council. The unitary authority serving the county.

HMG: Her Majesty's Government.

kW: KiloWatt, a thousand Watts (qv)

kWh: Kilowatt hour. A measure of energy used or delivered. One kWh is the UK standard *unit* of electricity. Multiples used include MWh; megawatt hour and GWh, gigawatt hour

LSOA: Lower Super Output Area, a census aggregation of about 1500 persons used to compile and manage data.

MoP: Member of the Public, person approached for interview.

MW: Megawatt, a million Watts (qv)

NIMBY: Not in My Back Yard. An often disparaging term used to label opponents of novel developments.

NFFO: Non Fossil Fuel Obligation. An early UK renewable support scheme, quickly replaced by ROCs.

O&M: Operation and Maintenance, variable project costs incurred during the productive life a project, such as fuel, spare parts, staff time.

ONS: Office of National Statistics. Source for census data and projections.

RICS: Royal Institution of Chartered Surveyors.

ROC(s): Renewable Obligation Certificate. An obsolete but still active support regime designed to ensure that major energy suppliers source a specified proportion of their electricity from renewable sources.

ROCE: Return On Capital Employed; the annual yield from combined equity and loan capital employed in a business.

W: Watt, SI unit of power. Used to quantify likely output from a generator or demand by an appliance. Multiples used include kW, kilowatt, MW, megawatt and GW, gigawatt.

WECS: Wind Energy Conversion System. Generic term to describe turbines used to generate electricity.

WoTs: Well off Techies; Term coined by Harper (2008) to describe rural autonomy enthusiasts supported by income from an unsustainable job or other wealth.

List of Figures

By number; title, and source if not original.

List of Tables

1 INTRODUCTION

1.1 The origin of the question " Are smaller turbines the way forward for wind energy in Herefordshire?"

It begins with a planning decision, a letter to a newspaper, and a huddle of activists. The planning decision was conditional approval of Herefordshire's first and so far only major wind farm project, just four turbines, at Reeves Hill, a remote site at the county border with Powys. (ukplanning.com 2010). The letter to the local newspaper put forward the view of a local environmental conservation group, that the county should reject any further large turbine developments in favour of smaller turbines in small groups. (Gunn-Wilkinson, 2009: **Appendix 1**) The meeting of the local activist group discussed potential of combining a campaign by Proven Energy Ltd., (makers of small size wind turbines) to promote “wind crofting” (Proven 2010) with the window of opportunity presented by the imminent arrival of "Feed in Tariffs" (FiTs) for renewably generated electricity in the UK. (Department for Energy and Climate Change (DECC) 2010)

This study is predicated on the assumption that wind energy projects as a whole are both good and necessary to provide local energy resilience as hydrocarbon based energy becomes scarce and also to reduce carbon dioxide emissions from fossil fuel use. (Fenderson 2006; DTI 2007; EST 2008) The output of the study is intended to be applicable to models of type or types of project suitable for local ownership and control which will gain widespread *local support and investment*. Simultaneously it aims to demonstrate clearly the consequences in terms of energy return on energy investment (EROEI) and also financial returns of opting for projects at various turbine sizes. The study does not aim to prescribe specific solutions, it aims to facilitate good policy formation among new and existing stakeholder groups. The path to policy is built from a combination of understanding present knowledge and beliefs about wind energy systems and bringing in the best available technical and academic resources to empower local groups to create their own wind energy projects. This places the study firmly within the conceptual framework of the advocacy/participation model (Creswell 2009). It includes a mixture of methods and encompasses different sociological and political theories(ibid). It is also necessarily, due to time constraints, exploratory and preliminary.

1.2 How did we get here ?

The history of wind energy development in the UK is entwined with the story of the UK's unique style of support regime. Unlike early adopters of both the technology and a feed in tariff support regime the UK came late, with no significant indigenous manufacturing capacity beyond off grid micro generators (Proven, Rutland) and forced wind energy onto existing energy corporations through the Non Fossil Fuel Obligation (NFFO) and then Renewables Obligation Certificates (ROCs). All this resulted in an industry which began at the largest available scale, corporate owned multi Mega Watt turbines in clusters at the best available onshore sites. According to Mitchel and Connor (Mitchel & Connor 2004)

> *"The Non Fossil Fuel Obligation (NFFO) did not deliver deployment, did not create mentors; did not promote diversity; was focussed on electricity and was generally beneficial only to large companies. A new mechanism, Renewable Obligation... is also beneficial to electricity- generating technologies and large established companies only."*

(Article abstract)

Against this, a small number of community owned projects, or third sector ethical businesses attempted to build an industry on the local co-operative model so successful in the earlier stages of the technology in Denmark and Germany. (Agterbosch et.al 2004) See also **Figure 1.1.**

Figure 1.1 The innovation system for wind energy technologies showing main actors involved and flows of influence, funding and knowledge. (Foxon et. al.2005)

This chart from Foxon and others (Foxon et. al. 2005) illustrates the state of the UK industry in 2005; with planning flagged as a key condition impacting onshore projects. It also shows the importance of the electricity supply industry, through ROCS, as a key player in project development. Note the absence of any reference to community or co-operative projects, which remain few and of limited size.

1.3 Who cares about wind energy developments?

Because wind is a crucial element of UK Government carbon emissions reduction strategy (DTI 2007) considerable effort has been focussed towards understanding public perception of and reaction to wind energy projects. This has largely studied reasons for opposition and has mostly been directed to overcoming this delaying factor in the widespread implementation of the core policy (van der Horst & Toke 2010, Aitken 2009 Haggett &Toke 2006, Bell and others 2005, Wolsink 2005). The important summary paper by Aitken (2009) discussed below, critically challenges many of the assumptions within this body of work. Previous attitude survey work has shown that public attitudes to wind farm projects follow a reliable curve during the initial stages of the project's lifespan. From widespread general support prior to proposals, once a project is suggested in a specific location local attitudes swing against it, reaching greatest opposition during the messy and disruptive construction phase. Following commissioning into service acceptance once more prevails, perhaps even exceeding previous support levels. In summary;

> *"Time and again, surveys have found that people’s fears about the prospect of windfarm development have proved to be largely unfounded, and that the reality is less visually intrusive, noisy and despoiling*

than they had expected. Indeed, it has been shown that attitudes to windfarms have a longitudinal dimension, typically following a U-shaped progression through time (Gipe, 1995; Devine-Wright, 2005; Wolsink, 2007): initially positive responses (when no nearby schemes are planned) are replaced by more negative assessments (when a local windfarm is proposed) and then these in turn are followed by a return to positive attitudes once locals have gained personal experience of the windfarm in operation. "

Warren and McFadyen 2010 (Warren, C. & McFadyen, M. 2010) p.210

This raises the question of why we cannot shift opinion directly from initial state to final state, missing out the intervening opposition state and hence speeding up project implementation. The planning process for the Reeves Hill project was long drawn out, having been called in by HMG and then returned to the county Unitary Authority for local determination. In common with most large scale wind turbine projects It saw the emergence of local organised opposition combining with opponents from further afield and able to muster considerable resources of talent and material to make their case. Only the opposition materials submitted through the online planning comment system are available for detailed study. Of the fifteen letters of objection posted on UK planning portal (ukplanning.com) eight were from local addresses including two from one address; the senders included representatives of the National Trust, Ramblers Association, one Doctor and two full Professors. There were many other comments, both for and against, made by direct contact with planning committee members. The Herefordshire County Council (HCC) planning case officer reports a total of around 1500 public responses, two thirds of them objections. (P. Mullineux; Personal Communication May 18th 2010). It was not clear how many of these were multiple copies of the same document sent to each committee member, but they were supposedly sorted for address of origin. (Herefordshire Council Planning Case summary received as email from case officer 19.5.2010) The following summarises the content of these responses, (insufficient data are available for a formal discourse analysis such as employed by Haggett and Toke (Haggett & Toke 2006))

5.14 260 households have responded in support of the application. These are mainly from residents both in the immediate vicinity and in the wider Marches area. There are also letters of support from addresses in other parts of the United Kingdom.

The key issues raised in support of the application can be summarised as follows:

- *Will provide clean sustainable development of low carbon energy.*
- *Will assist in reducing carbon emissions and thus contribute to lowering greenhouse gases.*
- *Herefordshire Council needs to contribute towards helping reduce carbon emissions.*
- *Impact on surrounding landscape is subjective with little impact on biodiversity.*
- *The proposed community fund will be an asset to the local Parish Council and stakeholders.*
- *Impact on local tourism will be negligible.*
- *The proposal will contribute towards the local economy.*

5.15 1053 objections have been received from many households in the immediate locality, the Marches area, as well as others from throughout the UK and abroad. These include an objection from a local action group known as 'Stonewall Hill Conservation Group'.

The key issues of concerns raised can be summarised as follows:

- *Impact on the surrounding landscape.*
- *Impact on Offa's Dyke and Glyndwr's Way.*
- *Impact on the surrounding historic and cultural heritage.*
- *Concerns about damage to local wildlife.*
- *If approved would lead to further applications for additional turbines.*
- *Queries as to whether wind farms do actually reduce carbon footprint.*
- *Impact on private water supplies to local dwellings.*
- *Will create unreasonable noise generating electricity.*
- *Will have a significant detrimental impact on local tourism.*
- *Loss of value to surrounding dwellings to the application site.*
- *Surrounding public highway infrastructure is inadequate to carry the traffic needed in order to construct the proposed development.*
- *Ice shards deposited on turbines.*

Note the difference between paragraph 5.14; "*260 households have responded in support"* and paragraph 5.15 "*1053 objections have been received from many households".* Unless the method of counting is consistent between objections and support this method of estimating local opinion is worthless. No satisfactory explanation has been offered for this.

1.3 What the polls tell us.

The objector's comments (ukplanning.com 2010) include challenges to published opinion polls claiming that they are biased or even rigged in favour of project developers. This claim may need to be addressed. Previous UK work has largely concentrated on studies of populations immediately impacted by wind farm projects, (Dent and Sims 2007; BWEA 2005); or on studies of the general population as part of wider examination of attitudes to energy policy (McGowen and Sauter 2005). The latter paper summarises results from a range of individual studies including comparison of studies revealing changes in public attitudes over time. Issues covered in the studies include attitudes towards different types of energy source and in the case of wind, both general and specific localised impact studies. The authors note

> *"The issue of agenda setting can be seen as of particular significance with respect to the purposes of polling and the way in which polling is conducted. In highlighting this factor we are not ascribing any particular motives to those commissioning the polls studied. However it is not unreasonable to assume that many of these polls are commissioned as much to shape the public agenda as they are to gather information on public attitude. Most of the organisations involved in polling have specific causes or interests which they are seeking to promote or defend. Interest groups have commissioned one third of relevant studies in the UK over the last 5 years."*

McGowan and Sauter (2005) p28

This highlights the ethical risks inherent in any attempted polling or other research by parties engaged in the social/political process of implementing renewable energy (or any other) technology. It demands a high standard of work in polling design and implementation, and integrity in communication of intention.

> *"5.7 Activists, brought in from elsewhere by the Developers, set up stalls in local markets and even outside schools to canvas opinion as to whether people support renewable energy, and wind power in general. That response was then taken, and the figures used, to signify support for their specific scheme. As one would expect, many people were concerned and supported a broad renewable strategy, but did not expect their support to be submitted to planning authorities as support for a specific wind farm,"*

Comment to Reeves Hill application submitted by Dr.Murray, quoting from evidence to parliamentary select committee by Davis and Davis (ukplanning.com2010)

1.4 How do Demographic factors influence opinions?

Only a small number of studies examine demographic factors in relation to opinions. The following comments,(**Table 1.1)** specific to wind energy projects, are derived from a total of 5 out of the 30 survey reports examined by McGowen and Sauter;

Table 1.1 Demographic factors and wind energy opinions up to 2005			
Demographic factor	Source poll	For wind	Against wind
Age	DTI, Scottish Executive (2003)	*35 to 44* y.o.	*16 to 25 and over 65*
	Devon, MORI, Regen (2004)		*60 y.o.*
	Somerset County Council (2004)	Younger	Older (+ve correlation)
	Guardian	*25 -64* 72% *16-25 and 65+* 60%	
Sex	DTI Scottish Executive 2003		Men 16% Women 21%
	Devon MORI 2004	Men 82% Women 70%	
	MORI, Regen SW 2003	Men 86% Women 81%	
	Capibus (2003)	Men 80% Women 67%	
Socio-economic group	MORI, Regen SW and Somerset CC 2003/4	AB	
	Capibus 2003	AB 83% DE 63%	
	Guardian	AB 72% Others 60%	

(Extracted from McGowen and Sauter 2005)

None of the evidence gathered here allows us to separate any of the indicated support or opposition from the agreed general support offered by the whole population, except in small variations. It is impossible without knowledge of questions posed and sampling used to extract more meaningful knowledge. To summarise, these results show both young*est* and old*er* age groups, women, and less well off groups are slightly more *against* wind energy than their opposites, within a context of overall support.

1.5 How does proximity to wind energy projects affect attitudes.?

A series of studies have examined how attitude varies according to proximity, that is, how close the individual *feels* to the matter; and salience, or how important the issue or location is to them. As van der Horst puts it

> "*In order to assess the nature and strength of concerns about proposed facilities in one's "backyard" it is essential to be able to identify what surveyed individuals consider to be locations that are of great importance to them."*

Dan van der Horst (2007) p2707

In other words there may well be objectors to a project who consider themselves stakeholders despite living at a physically distant place such as those with an interest in landscape value, wildlife or recreational uses. The U shaped curve of support over project time is also seen to be distance related by the same writer

> *"..risk perception of the new and unfamiliar is an important factor in peoples' dislike of proposed wind farms and that with the actual local experience of an existing wind farm this reason for opposition disappears. ...people living further away from an existing windfarm are more opposed to it; they lack the local experience to alter their perception of some of the impacts.*

(ibid)

So it seems that opponents who consider themselves local to a project which is beyond their day to day horizon may never recover from their reaction to it. The question of salience can be illustrated by who may have attachments to locations outside of utilitarian values; landscape *quality* for example. On page 2709 van der Horst (ibid) suggests

> *"people who have moved into the countryside as a lifestyle choice and are less dependent on the rural economy (eg retired 'townies', commuters, second home owners etc.)"*

and quoting Woods

> *"In-migrants will subsequently act to protect their financial and emotional investment by opposing developments and activities that threaten the perceived rurality of their new home. In this way identity and material interest are collapsed together as a motivating force for political action"*

(Woods 2003 p312)

This is not to deny that there may be equally salient feelings among members of the native population. By restricting this study to a single county opportunities arise for all these types of factors to influence the outcomes in a survey.

1.6 Is there a general explanation for localised opposition?

Bell and others attempted an explanatory analysis in a paper defining a range of possible accounts for the "Social Gap" between supposed widespread support for wind energy and amount of local opposition to actual projects. (BELL *et. al.* 2005) They offer a theoretical understanding based on differentiating individual from social responses, and offer these explanations;

1. Democratic Deficit; the outcome of the permitting process does not reflect the will of the majority.
2.The Qualified Support Explanation. The general support shown fails to account for respondents possible reservations which may be directed to specific projects.
3. The Self Interest Explanation. Suggests the respondents perceive their greatest good derives from opposing a project. This may be an example of supposed NIMBYism, or simple opportunism.

(Bell *et.al*.2005 pp461-466)

The Democratic Deficit model relies on the assumption that decision makers in the process, the planning committee, are in disagreement with their local electorate, which may well be untrue. Van der Horst and Toke (2010) used a database at Lower Super Output Area (LSOA - a spatial/statistical aggregation of about 1500 persons) in authorities where wind farms applications had been made, to discover many significant indicators within the local population and other geographical characteristics to predict planning outcomes. Their evidence suggests the democratic deficit model fails at the local ward and parish level.

Given the comments above on the validity or credibility of surveys item 2 in this list needs exploring. Even the most vigorous opponent bodies to wind energy projects at a local level have policies which support the technology in general.

"CPRE believes there is a role for wind energy in providing electricity in the UK but the intermittency and major visual impact of onshore wind turbines limits their potential contribution. Their location and extent need to be carefully controlled."

CPRE 2009 p2

Thus support is qualified by certain conditions being demanded. Examples of typical conditions include many variations on the Landscape/ visual intrusion theme, but also wildlife issues, local water supplies, noise impacts, television interference (TVI) archaeology etc. The UK co-ordinating group for opponents to wind farms, Country Guardian, provide local groups with materials for raising issues in the planning process based on economic arguments and general objections to the technology as well as the following categories :

- *Landscape degradation and wildlife*
- *Noise, shadows and flicker*
- *Danger and nuisance*
- *Property, tourism and employment*
- *Misrepresentation and manipulation*

(Country Guardian website 2010)

Despite this, their campaign manifesto clearly states

"It is the impact of these industrial installations and their side-effects that are opposed - not wind power itself"

(ibid)

It must be noted that a qualified supporter may be an organisation as well as an individual. Self interest can range from concern over a lost view, lost property value, to seizing the opportunity to cash in by claiming some benefit from the project in exchange for withdrawal of an objection, again this class of objector could also be an organisation. It may be difficult to differentiate between genuinely protecting a legitimate interest and outright opportunism so great care is required. Aitken (2009) warns against simplistic NIMBY labelling of objectors and criticises five key assumptions in the literature:

1. *The majority of the public supports wind power.*
2. *Opposition to wind power is therefore deviant.*
3. *Opponents are ignorant or misinformed.*
4. *The reason for understanding opposition is to overcome it.*
5. *Trust is key.*

(article in press,no page numbers)

She concludes that researchers have been insufficiently critical of surveys, and that more respect should be offered the opponents' positions. She demonstrates from within the literature that opponents are often better informed about issues and technology than supposed and suggests they cannot be 'converted' by information and education campaigns. The matter of trust touches on how citizens engage in civic society and their relations with other relevant actors such as councillors, planning officers and developers; and also on how people generally relate to scientific and academic knowledge.

This study is an attempt to invert these processes by finding proposals for projects that ought to attract the highest possible level of support; rather than trying to overcome opposition to projects which excite effective opponents and hence suffer delay. The proposal that small groups of smaller size turbines would be suitable for wind energy development in the county begs the question of who would oppose or agree to it ? In other words, would there be significantly less opposition and therefore a much quicker passage from proposal to generation. The promotion by Proven of "wind crofting" (Proven 2010) suggests a route to developing wind energy projects in a way which ought to arouse less opposition simply by using arrays of small turbines (which they manufacture). This begs the question, in the new era of Feed in Tariffs, of the economic and energy viability of different scales of project, i.e. would they represent the best use of the available resources, or provide an acceptable return, or both, or neither.?

1.7 What influences Planning decisions in the UK?

The position of the UK Town and Country Planning system as a crucial factor in wind energy development deserves critical theoretical political examination. The process itself involves both democratic and legalistic elements involving collective consensus and yet at the same time adversarial means of conflict resolution. It is sequential in time and hierarchical in levels of action. **Table 1.2** gives a simple illustration of what happens at various stages of the system. It must be noted that applicants, supporters and opponents can act at all levels within the hierarchy. The objectives of developers can range from simple profit in the case of a transnational corporate developer to implementation of a favoured technology by a community energy company. In the event of recourse to law (ie an appeal to the High Court and beyond) the actor is legitimised by evidence and resources; in other words the appellant must have a case and the means to sustain representation and/or bear costs in the event of defeat. Lack of either is a barrier to this level of action, which may have an impact on the eventual actions of opposition groups or developers. This does however require of all parties in the process a high standard of quality control applied in all legally required evaluations; Environmental Impact Assessments and Noise monitoring being outstanding examples as any flaw in these may be the basis of legal challenge at a later stage.

A number of studies have applied discourse theory in attempts to understand wind farm siting decisions, with a majority favouring the view that it is a consensual process reaching towards agreement on acceptable locations, as reflected in attempts to overcome objectors by reasoned arguments and attempting to account for the failure of this approach (Aitken 2009, Wolsink 2005, Hagget & Toke 2006). This would fit within the theory of civil society proposed by Habermas

> *"The communicative rationality...brings along with it the connotations of a non coercively unifying, consensus building force of a discourse in which the participants overcome their at first subjectively based views in favour of a rationally motivated agreement"*

Habermas 1987 pp 294, 315 (as quoted by Flyvberg 1998)

Alternatively, looking at **Table 1.2** the process may be seen in terms of the application of power and/or influence by actors within society to bring about their preferred outcomes (Stevenson 2009). This accords more with the thinking of Foucault who sees a social narrative in terms of conflict and power

> *"to criticise the working of institutions which appear to be both neutral and independent; to criticise them in such a manner that the political violence which has always exercised itself obscurely through them will be unmasked, so that one can fight them."*

Chomsky and Foucault 1988 (quoted by Flyvberg ibid p.223)

It may be shocking for rural parish councillors to see their superficially genteel processes described in these terms, but for marginalised micro cultures such as Gypsies and Travellers, Protest Camps or Low Impact Development groups this would be recognised as a true full and accurate description of how the planning system actually works. Wind turbines are a new element being brought into landscapes and discourses for understanding their impacts are not yet fully formed, nor is it yet possible to predict who will oppose or favour them in specific cases.

Table 1.2 Types of discourse within UK Town and Country Planning system

Level/ Actor	**Legitimisation of Actors**	**Framework(s) of discourse**
Existing law and practice	Statute	Consensual acceptance
Government Policy	National elections	Advocacy
Local Plan Policy	Local Elections	Consultation, Consensus, Advocacy
Application	Applicant	Own objectives (various)
Consultation	Statutory definition	Legalistic, Advocacy,
Support	Self selected	Advocacy, Consensual
Opposition	Self selected	Adversarial, Conflicting, consensual
Determination	Councillors, locally elected	Legalistic, Adversarial, Consensual
Appeal	Statutory Appointment	Legalistic, Adversarial,

Table 1.2 Types of discourse within UK Town and Country Planning system		
Level/ Actor	**Legitimisation of Actors**	**Framework(s) of discourse**
Enforcement	State authority	Adversarial, State Power
Recourse to law	Evidence and Resources	Legalistic, Adversarial

The requirement of this study therefore is to determine those factors identified in the existing body of work which can impact on achieving a consensus or provide appropriate tools in an adversarial conflict (according to the conceptual framework employed). The existing work on demographic factors relating to attitudes is unclear and no work compares present day turbine size options related to attitudes. To help determine a proposed optimum size of turbine the public choice has to be tested for energy and economic value. If in fact it turns out that this is a chimera then that too is worth knowing and the policy consequences explored. Habermas (1990: 93) explains that validity is defined as consensus without force:

> *'a contested norm cannot meet with the consent of the participants in a practical discourse unless . . . all affected can <u>freely</u> [zwanglos] accept the consequences and the side effects that the general observance of a controversial norm can be expected to have for the satisfaction of the interests of <u>each individual'</u> (emphasis in original).*

(quoted in Flyvbjerg 1998)

Truth remains multiple, subjective and negotiable, but the need for new renewable energy projects is ever urgent.

2.0 Methodology

The research underpinning this study is composed of two principal sections, an opinion survey and a technical/economic assessment. The methodologies are considered separately, beginning with the attitude survey.

2.1 Methodology of the attitude survey

The methodology sets out to address the question: ”Are public attitudes towards potential wind energy developments in any way related to the *size* of turbines proposed". It is also required to discover what sort of people supporters and objectors are, in other words does attitude bear any relation to demographic factors.? Related matters of interest are public perception of turbine performance and attitudes to local ownership and investment. The instrument chosen to measure the supposed construct "attitude bias" is an opinion survey. This should permit comparison to previous work using results from similar instruments, even if details are unavailable. Use of such a tool implies positivist (something exists to be measured) and determinist (the question can be answered from the measurements) assumptions (Cresswell 2009).

The decision to examine turbine size as a critical factor immediately placed constraints on the type, design and execution of any survey. To overcome possible limitations of meaning in common language graphical comparison cues were preferred to verbal descriptions. This requirement to use graphical cue cards illustrating a range of turbines along with scaling information makes the core of questioning a *visual* process; which may also be dependant on a culturally determined frame of reference (see notes on trial of cue cards in **Appendix 2**). The possible need for interviewers to explain the meaning of combined images effectively ruled out use of telephone polling. It must be noted that using telephone polling or even automated voice systems for a cash rich business consultancy or political campaign the cost advantages over face to face interviewing would give these options more merit; but for a single researcher with time rather than financial and technical resources this does not apply (Groves 2004).

The options to use postal polling or enlist the aid of local print media to distribute a questionnaire both present obvious issues of cost and the inevitable self selection of respondents. These would also offer enthusiasts either pro or anti opportunity to 'game' the survey by pressing their associates to respond in ways aiding their cause.

This left interactive online survey, extensive depth interviews and random street polling using a structured questionnaire as available techniques. For such a broad range of factors a preliminary extensive interview based survey was considered (Creswell 2009). In order to establish sampling frames this would depend on creation of a protected data base within data protection legislation and would require personal data to select quotas of subjects representative of the general population. Such a survey would necessarily be either largely qualitative or lacking in statistical correlation to the general population or both. Consideration was given to fully polling an entire settlement with a self completion questionnaire and follow up interviews but again this would be challenging to compare with the general population and probably impossible to draw statistically meaningful insight from. For these reasons this type of study was rejected as impractical for a survey with this purpose.

A more up to date version of the extensive qualitative interview, a focus group study, would demand considerably greater resources than available to this researcher. Such studies are not normally intended to discover existing attitudes or opinions, but to assess likely reactions to new ideas or products. It would still leave issues around selection of group participants, how to recruit those with relevant views without overwhelming the study with committed pro or anti believers. There may well be a place for such studies in following up matters of interest revealed by basic opinion polling (Rowe & Frewer 2000)

To deploy a twenty first century solution, interactive online polling, is a strong temptation . However Herefordshire is poorly served by internet connection providers. Consequently broadband internet use is below average and there remain many households with no routine access to the internet (HCC 2010 (3)). In a presidential address to the American Association for Public Opinion Research, Professor Dillman observes;

> *"The internet has not served as an immediate source of salvation. It is limited by restrictions on access, an inability to develop sample frames, and response rates that are mostly lower than those achievable by telephone."*

Dillman 2002 p 473)

The risk of sample bias this would imply rules out use of an internet poll in this county. The same arguments apply to the potential use of web2 social networking channels with the addition that participants would be self selecting and at risk of being gamed by special interests.

The remaining option was the structured interview with a probability sample of subjects selected at random in a busy street or other public location. A number of issues arise from this choice. These can be grouped into design of questions issues and interviewing practicalities. A need was identified to make the process of interviews as straightforward as possible for both parties, making questions and possible response classes as similar as possible hence reducing mental demands on respondents and allowing simple pre-coded scoring. As the same questions were asked of different sizes of turbines there was also a need to keep the number of separate questions asked to a minimum. (Each turbine question requires ask/response sets for each size of machine).

The final selection of a quantitative survey method enables collection of responses to questions on all of the issues of interest (subject to question design and analysis) in a way which allows responses to be correlated across a range of variables. In this way it was possible to build up an impression of how the survey population may be expected to respond to a proposal for a new wind energy project in the county, and to extrapolate this to the general population of the county. This is critically dependant on the quality of the sampling. In addition it was intended to publish a public report of the survey findings through local media and to opinion shapers in the county to elicit responses to the findings; hence permitting some measure of qualitative appraisal of how the discourse around the issue is emerging locally.

2.2 Sampling methodologies.

Because the study aimed to produce predictive results applicable to the whole county it required a sample as close as possible to the population by a range of conventional demographic factors. Gathering this data along with responses to attitude questions also permits analysis of how attitudes vary with these demographic factors so extra value results for no additional work. To study a population first requires knowledge of it's composition according to criteria of interest, in the UK this data is contained in the national census. Two sources are used, “*Key statistics for Hereford County*” and “*The population of*

Herefordshire (November 2009)”. Both documents use data and projections supplied by ONS and were in this case downloaded from the HCC website (HCC 2010). Because of time lag from the last full census, and known significant population changes (op cit) in the intervening period, it was considered most appropriate to use secondary data projections rather than 2001 census figures. It is believed that ONS figures can be trusted to reliably represent the county population. Figures for the projected populations within the classifications are tabulated in Chapter, 4 Results (**Table 4.1**)

Verification of the sample validity

Because several different factors are of interest and it was impossible to anticipate strength of correlations it was considered that rather than attempt an experimental power calculation for sample size, to simply aim to gather 500 interviews. It was expected that given the opportunity to fine tune strata within the sample by daily data recording followed by targeting, a stratified random sample would be selected which closely matched proportions of categories (cells) into which the source population has been divided. The study relies on verification by chi square testing for the hypothesis that the sample is *not* representative with the null hypothesis that there is *no significant difference* between sample and population as a whole. Failing this, as a last resort final data could be weighted to correspond to the census proportions for any classes under or over represented.The issue of response bias is discussed further in the results chapter.

To suppose that refusers were driven by a deliberate wish to be excluded from the poll for reasons related to it's purpose requires a mechanism by which they have prior knowledge of the survey subject (possible given the number of days polling took) and an expectation that it is in some way *biased against* their own interests or position. This latter is hard to accept, but does place a burden on staff to not engage in discussions of their own beliefs and attitudes, or to give any hints or cues of pro or anti wind energy leanings. This was covered in staff briefings as it represents good practice for field survey work.

2.3 The classifications

Sex

Theoretically self explanatory either/ or categories, no attempt was made to consider trans gender or transexual respondents as separate groups. No issues arose in the field.

Age

The strata chosen for age groups are simply for convenience of grouping working voters into roughly similar bands plus retireds as a group to test survey scores against.

Socio-economic group

The socio – economic bands are more challenging. State of the art census classifications are more detailed than are suitable for this study. Because of the practical constraints of time and resources compression of the strata is required. Following the example of Mintel (Mintel 2010) survey of retail shopping, bands chosen are groups A plus B, C1, C2 and D plus E. This breaks the population very roughly into quarters. A potentially serious issue arises from the census treatment of people as economically active or inactive. In practical terms this means that no data are available for the socio-economic classification of retired persons. For this reason it is assumed that proportions of socio-economic classes are the same for retired persons as for active. There is a potential source of sampling error here; considered further in the results section.

Domicile

By which is meant the self determined response to the question “Do you live in town or the countryside”. Whilst it was theoretically possible to include questions to determine if the balance was representative, this would have required respondents to give sufficient address information to locate them within a specific LSOA, almost a full address. As this was considered too intrusive to maintain the desired “Rapport” and would have demanded considerable further analytical work for minor gain, this option was rejected. An inspection of the absolute populations from census data reveals that the county population is roughly divided into thirds between city, market towns and countryside; a balance reflected in the survey returns for this issue. As this was later found to be not significant no further work was done.

2.4 Methodologies for Interviewing.

A well designed and conducted interview should have no systematic or random errors. For consideration of how this was addressed see the following chapter on survey method. For a discussion of identified possible sources of errors impacting on the survey, see chapter 4, Results.

2.5 Methodology of the technical and economic analysis

Because the lead issue revolves around turbine size this part of the work seeks to discover how turbine size impacts on return on capital employed (ROCE) and energy return on energy invested (EROEI). The possible methods include direct analysis of primary data, use of published materials such as test reports, manufacturers data, or critical examination of meta studies within the literature. Owing to restraints of time and possible commercial privacy issues the approach chosen was to begin with suitable meta-studies; ie those covering sufficient range of project sizes; historic range and recency; and to calibrate these against easily available real time data from web sites and if called for, individual calculations from first principles. All papers used were sourced from those available within the restrictions of a UEL Athens account, there may be better sources elsewhere not available to this writer but for this study a sufficient range of material was found to establish some basic principles. Methodologies of specific analytical techniques are discussed in the main body, Chapter 5.

3 Methods

3.1 Survey Method.

From an initial questionnaire and cue cards designs a field trial was conducted on one day in the small market town of Ross on Wye. Valuable lessons learned were incorporated into survey materials; including changes to cue card images and both wording and order of questions. A field report and commentary is included at **Appendix 2.**

Practicalities of the interviewing process are closely bound up in the requirement to minimise errors which may occur during polling. Much of the theoretical basis for understanding likely sources of error stems from work in the mid twentieth century political and market opinion research in the USA (Igo 2006). Katz (1942) and Reisman & Glazer (1948) offer a methodological and a theoretical example of issues arising in work from that time for which no clear resolution has yet emerged. Oppenheim (1992) offers a set of “Interviewers' Principles of Performance” as a valuable aid to design. (No recent, comparably concise summary was found in other authorities, possibly because effort has been directed to telephone and now internet polling instead). Their application to this work is as follows. (*Italicisations* are paraphrasing from the source)

Impression Management: *The visual and verbal approach to the subjects, manner of speech and dress.* This also goes to the selection of staff for interviewing (See section on field staff below) Staff were asked to dress in a smart, not necessarily formal, way and to avoid any dress items, jewellery or decorations with extraneous connotations. Staff were equipped with clipboard folders bearing the clearly visible label “ Voter Survey” in an attempt to differentiate them from marketing or fundraising fieldworkers. Classic work in this field, such as Katz in 1941 (Katz 1942) barely scratches the surface of potential interviewer effects yet even the simple social status effects he discovered could not be controlled for in a survey with limited staff.

Rapport: Having begun *an interview the worker needs to establish confidence and trust from the subject*. Respondents were assured that no contact or other identifying details would be recorded, that there was no commercial interest behind the survey and if asked shown a University ID card to confirm the academic nature of the work. The question to determine if respondents live in a town or in the countryside should have no challenging underlying implications so served to help establish this rapport.

Cue Cards: (see **Figure 3.1**) A decision was made early in the design to use three sizes of turbines, a backyard or farm scale up to 15 kW, an older onshore commercial example at 400 kW as a medium scale and an example of a typical present day onshore machine about 2 MW as the largest size. These sizes are also related to the band boundaries for the newly introduced (April 2010) Feed in Tariffs (FiTs) for renewable generation. The visual cue cards showing different sizes of turbines are central to this work. It was required that they show turbines in relation to some more common recognisable object to indicate their relative size. Two types were tested during the field trial (See **Appendix 2**) with the final version being based on comparison to the 32metre diameter Number 1 dish at BT Satellite Groundstation Madley; a locally sited significant infrastructure facility familiar to the vast majority of respondents. In addition the images were edited to remove other scaling and ranging clues, ensuring they shared common examples of middle ground vegetation and were of similar colour intensity. Finally each card carried a legend stating the hub height of the turbine.

Figure 3.1 The cue cards.

The comparison image selected is of the 32metre diameter number 1 dish at BT Madely; a local sited telecommunications satellite link most respondents recognised.

Small Turbine
The turbine shown in this image is of a **Proven 15kw** on a 15m mast. The images have been edited together to show both objects in proportion. In addition, the card carries the legend " Mast height 15m"

(*Image and data : Proven 2010) used with permission.*

Medium Turbine
This turbine image is from the Goonhilly wind farm in Cornwall, among the UK's first commercial wind farms. One of 14 **Windane 34, 400kW** machines, with hub height of 40m.

(Image and data: Cornwall Light and Power 2010) used with permission.

Large Turbine

This image shows Turbine number 1 at Swaffham in Norfolk, rated at **1.6 MW** with a hub height of 67m. The image was edited and labelled to represent an 80m hub height; a more likely size at present.

(Image and data; ecotricity 2010) used with permission.

Prompts: *The use of pre-coded scales simplifies the mental process* required of the respondents in terms of the process itself, separate from any possible complexity or comprehension issues arising from content of the questions. This was especially valuable for the question on turbine effectiveness, but there are issues arising from the scale chosen (see below ; Question 4).

Question Order: As was revealed from the trial survey, *the order of questions has a crucial effect on the smooth flow of the interview.* The final order resulted from lessons derived from the trial and worked well. For some respondents keeping to the script was difficult, they wished to go back and alter previous responses. This was not permitted as it was believed first responses would have a greater level of internal integrity and be properly representative of the subjects' views.

Problem Respondents: . Because of the visual nature of the cue cards it was not appropriate to attempt to interview blind people (Hereford has a College for the Blind). Wherever encountered all other differently enabled people were included in approaches.

Situational Issues: The single most important of these is the refusers. Despite best efforts of Impression Management there was a very high rate of refusal discussed in more detail in the results Chapter. Another common issue was *partner interference*, mostly by men during interviews with women. In this case the responses were recorded as from the dominant or leading partner. Groups of young men together also gave problems attributing replies to a single respondent.

Language: Questions need to be worded in a way which is both universally comprehensible and yet also able to draw out nuanced views of respondents. This is potentially difficult for people who do not have English as their first language and a small number of respondents abandoned the interview due to language issues. Field staff were directed to hold strictly to precise wording of questions and where supplementary comments were either appropriate or forbidden. (Notes for field staff are included in comments to questions, below)

On this language point Oppenheim (op cit pp148) offers this cautionary note

> "*...how we can predict contextual effects on a question, or in what ways we can ensure that respondents will all use the same frame of reference in answering an attitude question. We lack strong theories about attitudinal constructs in people's minds...*

Since this was written there *have* been advances in the theory of attitude questionnaire construction, applying theories of cognitive psychology to question design. However according to Ornstein;

> *The better theorized understanding of survey responses and much more systematic body of empirical findings appear to have had only an incremental impact on everyday survey practice. The best contemporary survey research is done by people who know a lot more about survey design than their predecessors, but this knowledge must still be combined with the craft skills to create survey questions that people understand and can use...*

Ornstein 1998 pp41

3.2 Question design.

The questions can be divided into three categories; the *factua*l questions, age, sex and place of residence; the *classification* question to locate the respondents into a socio-economic group ; and the *attitude* questions, being the core of the survey. A theoretically more robust design of survey would employ a split sample and use alternative questions to measure the construct 'attitude bias towards wind turbines'. It is however challenging to imagine alternative forms of question to those used here which would permit both extreme views and conditionality in respondents; and to do this in two balanced questions comprehensible to MoPs (Ornstein 1998). There is a thorny issue of how to measure respondents awareness of turbine effectiveness; and if in fact any such measure can be anything other than a meaningless guess. See below (question 4) for the treatment of this.

The final Questions

The final questions are detailed here in the order they appear on the questionnaire, with guidance notes for field staff. Responses for each interview were recorded on a separate printed record sheet. For each question the type of response required was indicated alongside the question on the sheet. At the end of each day field record sheets were collected and the data coded and entered into a spreadsheet.

The lead in question;

" **Are you on the electoral roll in Herefordshire**"

is the capture question, to bring a member of the public (MoP) into the process but only if they are living in the county on a permanent basis, and are over 18. A 'yes' response was then followed by the question,
"do you have a few minutes to answer some questions about your views on wind energy?"
A 'no' at this stage was tallied as a refuser. A yes then leads into the survey questions proper beginning with;

1. "Do you live in a town or in the countryside"

If the respondent was unsure they were invited to make their own call as this would reflect any aspirational status in the mind of the subject and be a legitimate part of their attitude set. This was scored using a T or C on the record sheet, and entered in the spreadsheet as a 1 (town) or 2 (rural)

The subject was then told that they were to be shown pictures of wind energy projects and asked if they agreed or disagreed with some policy statements about them. They were advised to listen carefully to wording of the statements and be careful how they answered. On showing the first card the BT dish was explained first, and subjects asked if they knew it. The use of the dish image to show relative scale was explained, then the turbine image emphasised as being the subject of the questions, and the legend indicating mast height also pointed out. Subjects were asked to confirm understanding of all these elements and any doubts dealt with before proceeding. The first policy statement and question was then read out

2. " Herefordshire should allow these to be built anywhere they will work" do you; Strongly disagree, disagree, agree, strongly agree or neither?

This invites a response indicating bias in the direction of **UN-**conditional support. A conditional supporter will **DIS-**agree with the statement. If challenged, staff were told to explain that it was not a trick question and was to be taken to mean what it said and also that *opportunity may come later to express variations of opinion.*

The second policy statement followed;

3. " Herefordshire should not allow these to be built anywhere in the county"

with the same response options as previously. This invites a response biased towards outright opposition. A conditional supporter will **DIS-**agree with this statement.

For attitude questions, responses were placed on a Likert-type scale pre coded (-2 to +2) to indicate a +/- or 0 direction and strength of attitude. This is a widely understood method for scaling attitudes used in simple surveys of this kind, but it has drawbacks. (Cliff 2007, Jamieson 2004) It is a crude measure of what may in fact be a highly nuanced phenomenon - an individual's personal attitude towards an issue. It takes no account of the salience of the issue to the respondent, or their proximity to it (Wylie and Hague 2003). It also cannot place the response on a meta scale between a highly negotiable casual opinion and a deeply held fundamental conviction (Oppenheim 1992). Despite these shortcomings this scaling method does allow both direction (for or against) and relative intensity (the *strongly* option); whilst also permitting a neutral response. Also, as a monotonic scale, the policy statements (as above; Q.2 and Q.3) can be pitched as strongly or weakly as desired without excluding any possible responses; outside the zone of uncertainty a person knows if they agree or not; unlike Thurstone scales no -one can be left out (Newell 1993). Fundamentally, this scaling method places little burden of comprehension (apart from any complexities in the *content*) on interviewees, ensuring smooth progress through the task. As the two policy statements are logically opposed it was necessary to sign reverse the second score to ensure that direction of bias was maintained. This was done at data entry stage, an additional column included in the spreadsheet for the sum of these two values, indicating total bias score used in later analysis. A methodological issue arising from combining scores is discussed in the results and in detail in **Appendix 4**.

Finally the subject is asked to estimate;

4. "How many households electricity use would this machine provide for?" is it; less than 1, 1 to 10, 10 to 100, 100 to 1000 over 1000?

Staff were instructed to explain the meaning of the question as households *total units* of electricity per year rather than *peak demand.* As the aim of asking such a question is to determine the difference in average assessment of outputs compared to a nominal "true value" of some kind it is regarded as irrelevant that for most individuals the response may well be a guess. This approach relies on the phenomenon of "Wisdom of crowds" (Surowiecki 2004) and meaningful data being gathered with such a question is size and direction of the error; which can then be tested with other responses for significant correlations as well as providing an overall view.

This question invited respondents to locate their guess on a logarithmic scale (orders of magnitude). The respondents being given this range of choices enables them to use any prior knowledge or common sense understanding of technical matters to make a selection. No doubt the outcome of this question would have been very different without the cued options. Some error may have arisen due to the "correct" option for the largest turbine also being the final option offered, yet adding another higher option would have added further time to the process. To arrive at a score for deviation in both direction and size of this guess from the supposed "true" figure it was required to determine in fact how many households electricity use such machines would provide for. The relevant typical annual output figures for each turbine illustrated were obtained from operators or energy supply companies or both, then compared to typical county household use (DECC 2009). To arrive at the recorded score for this question, the scale value for the “correct answer” was subtracted from the given answer. Thus a 0 indicates a correct placing in order of magnitude of output, a negative score indicates the respondent *under* estimated, and a positive score an *over* estimate. Some respondents simply refused to attempt this question, their responses were coded to indicate this, and were not included in analysis relating to this matter.

For the following cards it is explained that procedure is the same, and on showing the card the BT dish is indicated as being the *same* dish and the turbine as being a *different* turbine, the height of mast legend pointing up scale. Once all three cards have been shown and responses recorded the next question was;

5. To the statement “I support wind turbines if they are locally owned” do you; strongly disagree, disagree, agree, strongly agree or neither?

This is a most dangerous question, being “double barrelled” *and* conditional. The objective of this question was to draw out the number of conditional supporters for whom the ownership of projects was a significant determinant of their support level, as this was found among issues raised in objection to some projects, and to gauge potential support for such a scheme. The possible responses are;

> *Unconditional opponent* – disagree (never supports)
> *Conditional opponent* – disagree if ownership NOT a relevant condition.
> *Conditional supporte*r – agree *if* ownership IS a relevant condition; otherwise disagree.
> *Unconditional supporter* – always agrees. Strong agreement may show *enthusiasm* for local ownership.

Those for whom ownership was not relevant or the question meaningless were most likely to score neutral.

If explanations were asked for staff were directed to offer a range of examples of models of local ownership, such as farmer/landowner, a company with local shareholders, a local authority, a community company or co-operative. This question was also scored, and recorded, using pre coded Likert scale values -2 to +2.

Following this subjects were asked;

6. “Given the chance would you invest some of your savings or pension fund in a local wind power project ?”

Only the yes/no options were offered to this question; so it is open to criticism of creating a an acquiescent or aspirational response set; ie that people may tend to answer yes in order to appear well off or financially sophisticated. There is some risk of respondents confusing *would* invest with *will.*

Responses were coded Y or N and entered into the data as Y =1; N = 2

The final demographic questions were introduced as helping to ensure that the survey represented views of all people in Herefordshire.

The interviewer noted sex of the respondent as M or F; entered in the spreadsheet as M = 1; F = 2 .

Subjects were asked to give their age. ('ladies of a certain age' were shown the option boxes on the question sheet and asked to indicate the relevant one - enhancing 'rapport'). The pre coded scores were entered directly as recorded.

Subjects were asked the usual occupation of the highest earner in the household, in the case of retireds, main occupation prior to retirement. Staff were asked to *not* attempt to code this, but simply to record replies as given. In the event of ambiguity, subjects were to be prompted for their highest level of academic attainment. At the data entry stage this information was interpreted by the researcher into classification strata as selected at design stage, requiring some subjective judgements, a potential source of systematic error. Some judgements were straightforward, for example a sole tradesman is a C2, but a tradesman operating a business and employing others is a B; but how to class a lone parent or unemployed person with a university degree? or a “professional medium”? There is also an issue of interpreting the job description; “Government servant” could mean any level within the Armed Services. No additional remedial measures were applied to address these issues.

Table 3.1 Variables, issues, and survey items

Variable	Issue in question	Survey item
Independant variables; Domicile	Does town or rural location relate to bias?	Q.1. Town/Countryside.
Sex	Does sex relate to bias ?	Q.7. Visual inspection.
Age	Does Age relate to bias ?	Q.8. Pre coded groups
Socio-economic group	Does s/e group relate to bias	Q.9. Main earner occupation
Turbine Size	Variation in bias with size	Cue card images
Dependent variables; Attitude bias	Strength and direction of attitude bias; conditionality.	Q.2 and Q.3. Paired opposite Likert-type scale.
WECS effectiveness	Perception of output	Q. 4. Locate on logarithmic scale
Approval of Local ownership	Is ownership an issue?	Q.5. Likert type scale
Investment choice	Possible investor in local project.	Q.6. Yes / No

After Creswell 2009

3.3 Survey procedural matters

Feedback and targeting thin strata

The schedule for interviews included a supplementary period for fine tuning strata cells within returns. That is if any groups by any demographic metrics were under represented then staff would be instructed to target these people for approach rather than rely on true randomisation; until the spread is restored to parity with census data.

Refusers

Staff begin with a blank record sheet. A Member of the Public (MoP) is approached with the lead question -"Are you on the electoral roll in Herefordshire?". If the MoP refuses to respond a tally mark is made on the record sheet. No mark is recorded if the answer no is given (despite the obvious fact that this may be an easy opt out for the unwilling). This continues until someone willing to be interviewed responds. The total of refusers is simply the tally total from all completed record sheets. No demographic data about refusers are attempted. It is considered unreasonable or impossible for survey staff to consistently estimate socio-economic group from visual clues only. Estimating age at the older boundary and around 18 years would also be challenging. (See also note on refusers in results section 4.1)

Selection of interview sites

The first decision was to only conduct interviews in the City of Hereford. As the city is home to about a third of the county population, and half the remainder live in the outlying market towns of Ross on Wye, Ledbury, Bromyard, Leominster and Kington this was considered a cost effective way of reaching a large enough street population to maximise use of staff time. Consideration was given to possible differences between populations of outlying towns on any measured factors either between each other or with the City and census data do show small differences in age distributions but for such a small study this was considered a negligible risk. The risk remains that people living in market towns may have significantly different opinions from city dwellers; only a larger study designed to engage with this issue could determine this. Assuming that a few staff would be available the original survey design was based on selecting sites which ought to yield random samples closely matching the source population, and to identify sites where a skewed sample could reasonably be expected if required. This analysis was based on examination of the Mintel retail shopping survey (Mintel 2010) along with a map of central Hereford showing locations of major retailers, car parks and public transport links (**Figure 3.2**)

After contacting local site managers of the supermarkets it was clear they would not be sufficiently flexible to enable use of their premises, requiring advance notice and giving priority to commercial and charitable uses of available spaces. From this it was decided to operate within the Hightown pedestrianised area close to car parks and bus links to both City and rural feeder transport. There were only a few occasions when this failed to yield sufficient passers by to justify the effort of continuing polling, all towards the end of normal working hours on weekdays.

Field staff

The literature frequently states that the best interviewers are clerically trained women between 30 and 45 years of age (Moser & Kalton 1971) but as no one substantiates this with evidence, it may be an artefact of the history of part time employments available to educated women. A number of volunteers were recruited from within this demographic, of whom all but one failed to show. The one that did take part was only able to work one short session and managed ten interviews. The remaining interviews were conducted by the writer, a man of mature years, which may have negatively impacted on numbers of responders. An alternative view is that such a person would be unlikely to be engaged in commercial interviewing, so may have had a beneficial effect on response rate. Either way these matters are beyond the reach of this study.

Figure 3.2 Central Hereford showing survey location.

A = Asda
S = Sainsburys
T = Tesco
M = Morrisons

All have car parks in addition to other public parking spaces.

(Map used with permission Codair Design & Publicity ltd. based on OS data)

4.0 Results

This chapter consists of the returns from the survey, including the demographic classifications of the sample and it's verification, a description of the responses to the attitude and belief questions; followed by the statistical testing of a range of hypotheses concerning possible relationships between the independent and dependant variables. Raw frequency data are shown in **Appendix 3**. The chapter ends with some postulates based on the analysis to be discussed further. It is acknowledged that the data would permit further more detailed and more subtle analysis, but this would go beyond the original aim of the work.

4.1 The Sample

Table 4.1 The survey sample classified by demographic criteria

Factor	Classification	Sample	Census
Domicile	Town	306	n/a
	Rural	194	n/a
Sex	Male	247	242
	Female	253	258
Age	18 - 29	84	71
	30 - 39	66	68
	40 - 49	104	93
	50 - 64	139	136
	65 and over	107	132
Socio-Economic Group	A+B	129	125
	C1	118	110
	C2	124	120
	D+E	129	145

Towards the end of the survey work a shortfall was identified in the number of older D and E group males. Field staff were directed to target this group during the final two days of polling with limited success. Alternative strategies were considered for reaching this group, abandoned in favour of firstly testing for validity of the existing sample then if required weighting the data. The sample was tested for validity using the chi square test to compare demographic factors between observed and pro rata census values. The Null hypothesis is that there is no *significant* variation between the composition of the sample and source populations; which is accepted over the alternative hypothesis. Details are in **Table 4.2.** This leads to a risk of a type 2 error. In fact the beta value of 75% indicates that this risk is unacceptably large for this sample, and therefore the data have to be weighted prior to comparison of results across demographic groups. In addition this means that overall scores will be biased according to the distortion of the sample from a true representation of the population. See Appendix 3 for treatments of this.

Table 4.2 Chi square test for sample validity

Factor	Observed	Census	O - E	X^2	X^2 Sum	df
Male	247	242	5	*0.1*		
Female	252	258	5	*0.1*		1
					0.2	
AGE						
1	84	71	13	*2.38*		
2	66	68	-2	*0.06*		
3	104	93	11	*1.3*		
4	139	136	3	*0.07*		
5	107	132	-25	*4.73*		4
					8.54	
S/E						
A+B	129	125	4	*0.13*		
C1	118	110	8	*0.58*		
C2	124	120	4	*0.13*		
D+E	129	145	-16	*1.77*		3
					2.61	
Sum					**11.35**	8

Data was weighted by first finding overall scores for each class in each demographic grouping. These scores are then applied to population cells according to census data and further analysed from those values.

Nonresponders.

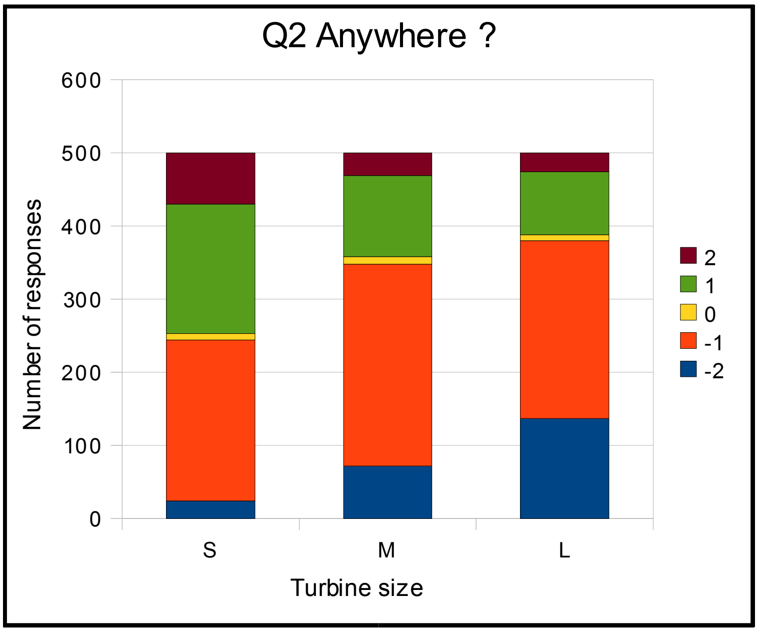
At this stage the number of refusers must be considered. A total 2361 persons approached declined to be interviewed against 500 that co-operated. Whilst no systematic technique was employed to differentiate between them, field staff indicated a high level of refusal when attempting to stratify for older manual workers, contributing to the shortfall of this group in the sample. The usual methods of handling non response in attitude surveys; comparison of early to late responders, testing for time taken to respond and comparison of respondents to non-respondents (Lindner et. al. 2001) cannot be applied here. The early/late comparison depends on the assumption that late responders are similar to non-responders, and an extrapolation from this. The targeted stratified sampling technique used in this survey precludes this. Response time is not relevant to a street interview survey, and as explained above no data were collected about refusers other than their number; preventing sample to non responder comparisons. None of these steps would protect the survey from the unmeasurable response bias effect, ie the hypothesis that the non responders would have given largely neutral answers, reducing the overall levels of the construct 'attitude bias' in the whole population.

4.2 Individual Attitude question results.

Question 2

2. **Herefordshire should allow these to be built anywhere they will work**				*Do you*
Strongly Disagree -2	Disagree -1	Neither -0	Agree 1	Strongly Agree 2

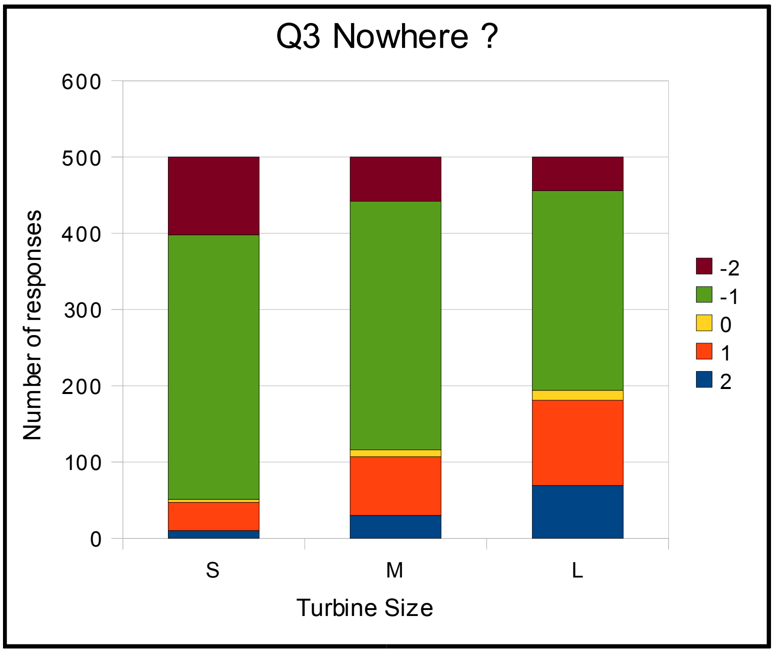
Figure 4.1 Frequencies of scores to Q2



Question 3

3. **Herefordshire should not allow these to be built anywhere in the county**				*Do you*
Strongly Disagree -2	Disagree- 1	Neither- 0	Agree 1	Strongly Agree 2

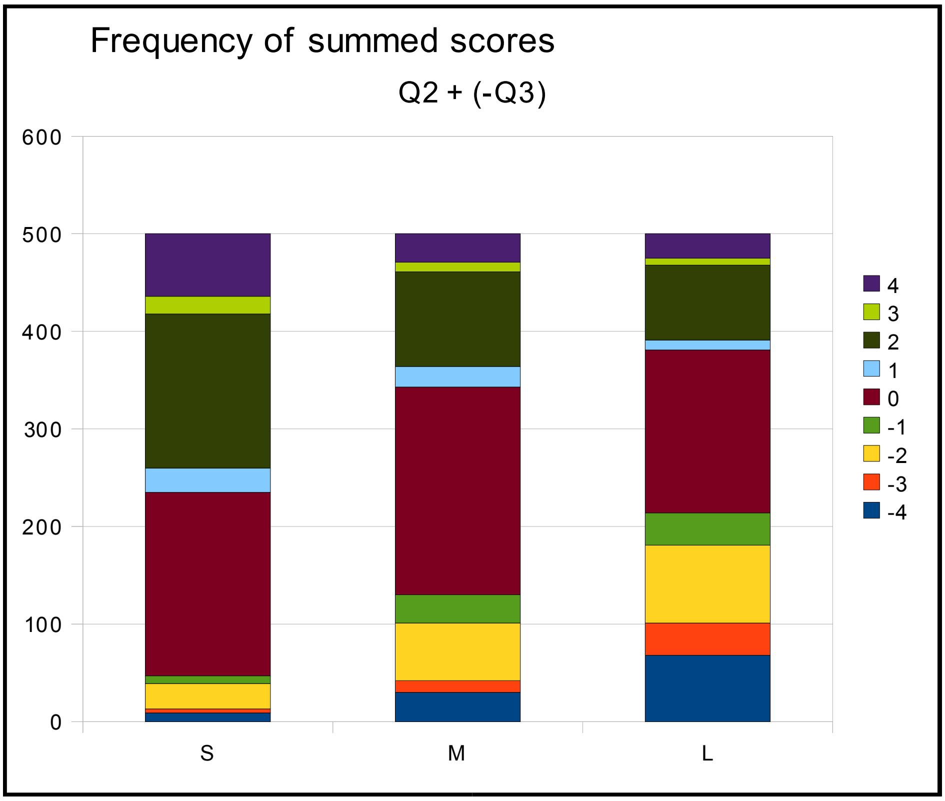
Figure 4.2 Frequencies of scores to Q3



As discussed above in the section on survey method question 3 is logically opposed to question 2, and a negative score indicates a pro wind turbine attitude. The values for the overall bias scores for each respondent are the sum of the scores from Q2 and the reversed score from Q3. In this chart a positive value indicates a tendency to be supportive of wind turbines of the given size, a negative score a similar bias. Because the questions were designed for this purpose, the conditional supporter is revealed by the 0 score (Figures 4.1 and 4.2 show this is *not* a result of neutral responses)

For a detailed discussion of the treatment of Likert - type data see **Appendix 4.**

Figure 4.3 Frequencies of summed scores from Q2 and Q3 (See Appendix 3 for tables of frequencies)



Weighted Frequency of scores

As the sample was found to be inadequately representative (as a type 2 hypothesis acceptance support error), data were weighted according to two factors most deviant from census cell counts, age group and socio/economic group. When calculated for each factor singly, these frequencies were found to differ slightly so an average was taken. This was considered acceptable over the more rigorous method of populating individual cells for every variable as the differences were very small. At all stages in this manipulation check sums were used to ensure accuracy of data inputs and rounding. The final table uses results rounded to whole integers.

Figure 4.4 Weighted Frequency of scores

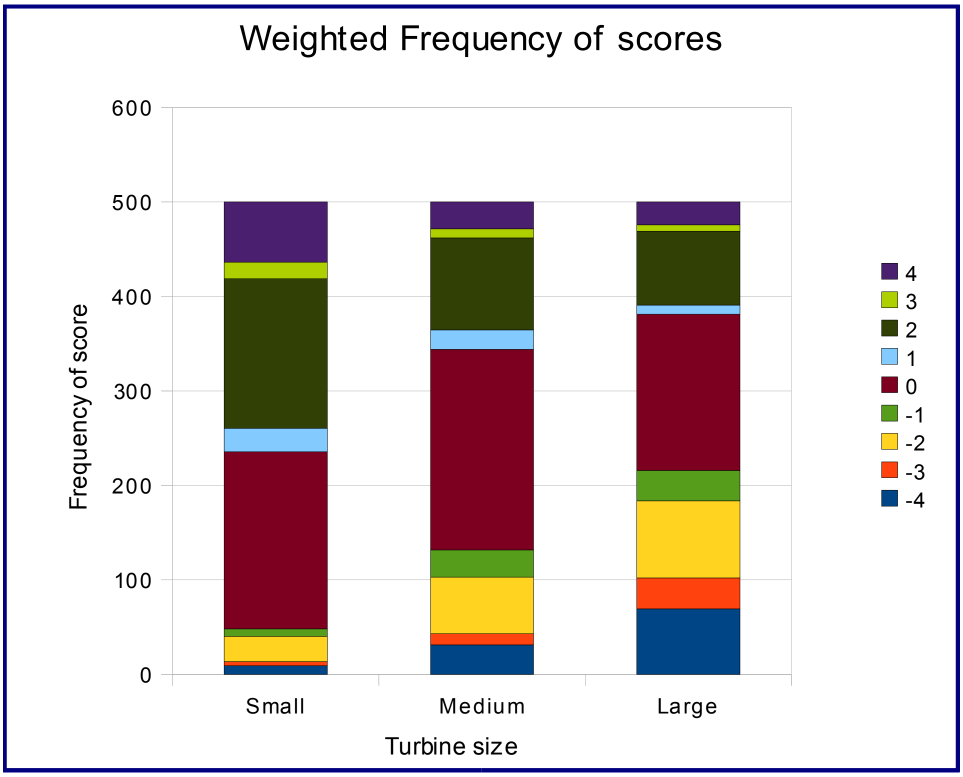


Table 4.3 Weighted frequency of scores N = 500			
Score	Small	Medium	Large
-4	9	31	69
-3	4	12	33
-2	27	60	82
-1	8	29	32
0	187	212	165
1	25	21	10
2	158	97	78
3	18	10	7
4	64	28	24

4.4 Interpretations of attitude results

Clearly the survey shows that for the sample, and by extrapolation from it, the population of Herefordshire, turbine size has an impact on their level of support/opposition to potential wind energy projects. The combining of the scores from Q2 and Q3 giving an overall bias score with a strong central tendency indicates the high level of conditionality in these attitudes. This combining also reveals numbers of respondents showing total support or total opposition (combined scores of +4 or -4) and allows us to examine who these people are. (See below; **4.9** Identifying the extremists).

Figure 4.1 shows that although half the sample agree that small turbines should be generally permitted, the remaining half do not. As this size turbine is just above the top limit for proposed permitted development of micro generation plant there is a suggestion that this group may feel aggrieved if their neighbours exploit the new General Permitted Development Order (GDPO) and erect 10m high turbine masts in clear sight. Surprisingly almost a quarter agreed that large turbines should be allowed anywhere they will work.

Figure 4.2 shows that inviting respondents to exclude wind turbines from the county yielded, among other things, the result that about three fifths believe there ought to be some place in the county for large scale turbines.

Whilst these returns clearly confirm previous polls showing high levels of general support for wind energy, they also confirm the conditionality suggested by Bell and others (Bell et. al.2005). At a local level this conditionality may be expressed as a "virtual" opinion waiting to be made manifest by a planning application (or permitted development); with the direction of reaction dependant on reason(s) for conditionality. For a "nimby" this may be simple proximity, for a nature conservationist it may be site specific but anywhere in the county.

4.5 Hypothesis testing

The core question in this study goes to the size of turbines; so the first test must be to determine if size has any bearing on bias scores. The null hypothesis is that bias scores are **not** related to size; the alternative hypothesis that bias scores **are** related to turbine size.

Table 4.4 Chi 2 test for significance of turbine size to response scores

Score	Mean	Small	X^2	Medium	X^2	Large	X^2
-4	36.47	9	*20.59*	30	*0.8*	68	*29.51*
-3	16.31	4	*8.87*	12	*1.22*	33	*16.68*
-2	56.13	26	*15.22*	59	*0.26*	80	*11.48*
-1	22.96	8	*9.88*	29	*1.42*	33	*3.81*
0	188.32	188	*0.01*	213	*3.08*	167	*2.82*
1	18.46	25	*2.36*	21	*0.26*	10	*4.19*
2	111.26	158	*19.85*	97	*1.74*	77	*9.83*
3	11.27	18	*3.51*	10	*0.23*	7	*1.94*
4	38.8	64	*15.95*	29	*2.8*	25	*5.39*
			96.25		*11.82*		*85.65*
			Sum				***193.71***
							df = 24

In this test expected score is the mean of frequency for the three sizes; or what could be expected if size was not relevant. The chi square value gives a probability of significance so high that it does not appear in standard tables. Table 4.4. There can be no doubt that attitude is significantly related to turbine size. The direction of this bias is absolutely clear from a simple inspection of response frequencies, with more negative scores for the large size and more positive scores for the smallest. It must be noted that scores for medium size turbines are not necessarily centrally located between large and small. Another approach to this data is to ask how many are for or against wind turbines in the county? How it can be answered is a useful exercise in manipulability of survey returns.

Table 4.5 For or Against ? N = 500			
	Small	Medium	Large
For	265	156	119
NOT For	235	344	381
Against	48	132	216
NOT Against	452	368	284

In this table all 0 scores are in the NOT classes, all negatives are *against* and all positives are *for.* So from these figures it can be said that more than half (284 from 500) are not against large turbines. Or it can equally correctly be said that only about a quarter (119 from 500) support large turbines. The high proportion of zero scores indicates the validity of the conditional supporter hypothesis advanced by Bell and others (Bell et. al. 2005).

4.6 Other questions results

The Effectiveness Question

4. **How many households electricity use would this machine provide for ?**					
No idea - z	< 1 - 1	1 - 10 - 2	10 - 100 - 3	100 - 1000 -4	1000 + -5

As described above the responses to this were scored according their deviation from a notional “correct” answer; yielding the following;

Table 4.6 Turbine output guess; error scores			
	Small	Medium	Large
Average Error	1.06	-0.49	-0.85
No. Correct	229	150	183

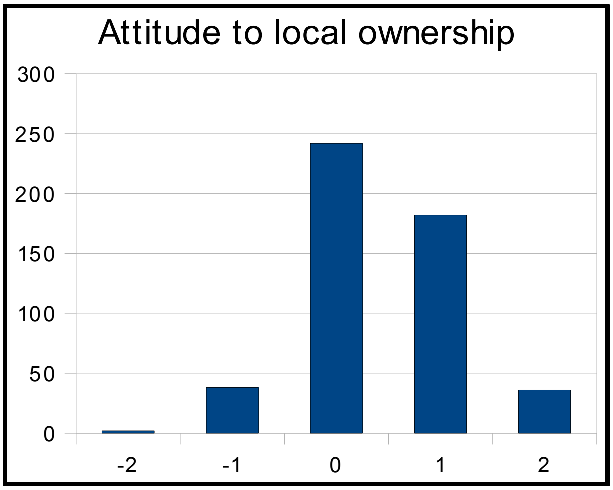
The large number of correct guesses for the larger size may be an artefact of the question format, as this is the largest option on the offered scale. A better option may have been to add another larger option to the cue scale. Despite this there is still an under estimate of nearly an order of magnitude. In contrast nearly half the respondents over estimated the performance of the smallest turbine by an order of magnitude or more. Despite having fewest correct hits the medium size yielded the most accurate collective guess.

The ownership question

5. **I support wind turbines if they are locally owned** *Do you*				
Strongly Disagree -2	Disagree -1	Neither 0	Agree 1	Strongly Agree 2

There are a number of possible responses and interpretations to this question; which was originally designed to find those conditional supporters for whom ownership of wind farms by outsider bodies (such as transnational corporations) is a major issue. The result shows the modal response is that this is not relevant, with the majority of the remainder indicating increased support.

Figure 4.5 Frequencies of scores to Q5



Investment Choice

6.Given the chance, would you invest some of your savings or pension fund in a local wind power project ? Y / N

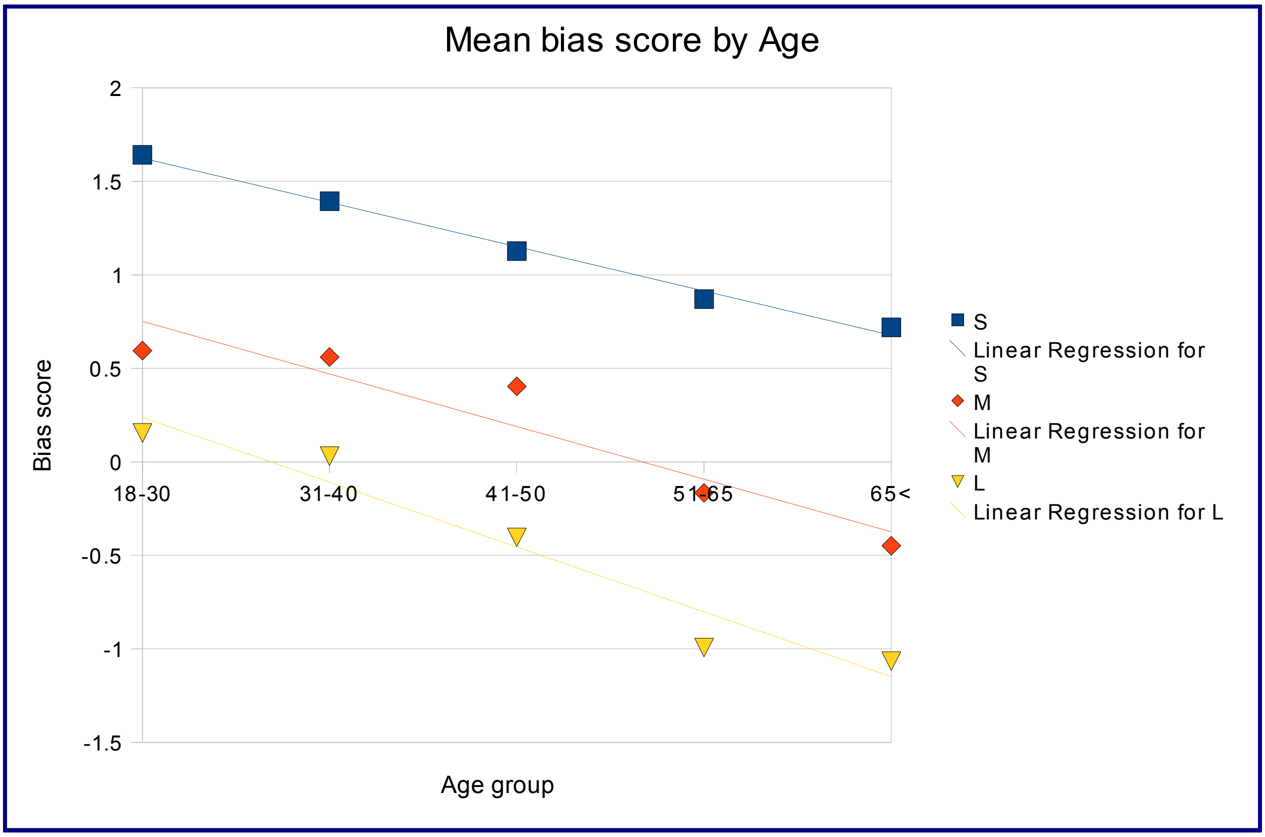
Table 4.7 Investment Choice			
Would you invest in a local wind power project ?			
Yes	286	No	214

Caution is needed with these responses, as respondents may be reporting a willingness to *consider*; as with any investment decision; rather than a positive commitment to invest. More subtly these results may the victim of a *response set* through which the respondent wishes to appear financially sophisticated. Like the previous question, staff report a lack of awareness among the respondents of how this could work; the most common response being lack of appropriate level of funds. Some even believed that Herefordshire as a whole lacks sufficient wealth for this to be viable. The safe conclusion from this data is that "NO" respondents will not invest; leaving large numbers of potential investors to be approached. (However some fine tuning may be available, see below; Potential investors))

4.7 The Demographic breakdown

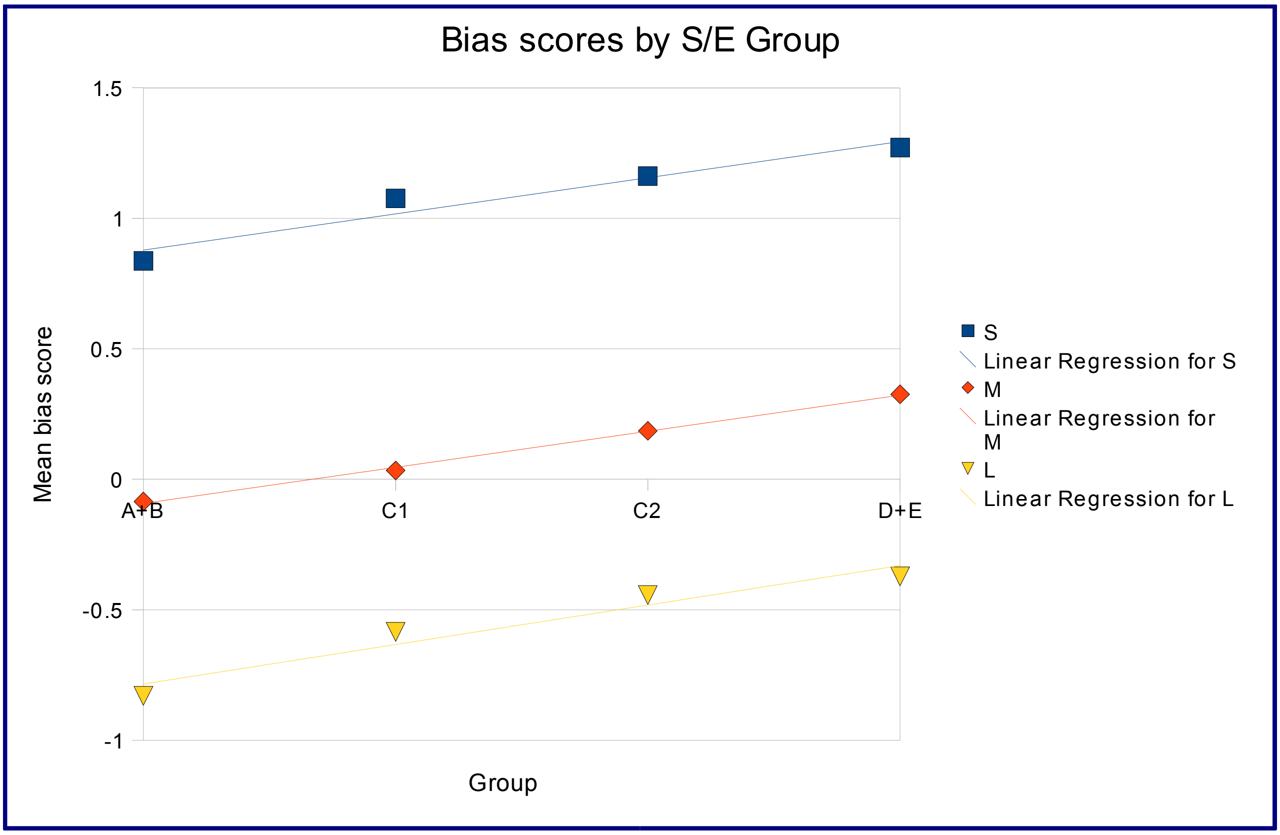
Demographic factors used to check sample validity also permit an examination of variation of attitude scores across these factors. As seen below (**Table 4.8**) neither domicile nor sex have significant correlations to attitude scores, but age and socio-economic group do. In these tests the data are sorted for the relevant demographic factors, weighted to correct the sampling shortfalls, then a mean bias score calculated from the summed responses as described above; giving mean bias scores for each factor for each turbine size. Note that this is not a measure of absolute *strength* of bias, but of *prevalence of likely bias* in that particular demographic. The weighted average bias scores are shown in **Appendix 3.** The graphs below include linear regression lines as calculated by the spreadsheet software.

Figure 4.6 Mean bias score by Age group



The bias score here is clearly falling away from strong support among the young to strong opposition from senior citizens. Under 40's show positive scores for all sizes of project. Age 50 is roughly the median of the whole population so the older half of the respondents are more likely to be opposed to both medium and large size turbines. All groups show more support than opposition to small turbines.

Figure 4.7 Mean bias score by Socio-Economic Group



As in the case of bias varying with age, here is a clear trend showing that opposition is greatest among higher socio-economic groups and support higher amongst the less well off. Perhaps the most important detail from this graph is that all groups show a greater measure of opposition to than support for large turbines, and all but the first group show greater support than opposition for medium size ones.

4.8 Hypothesis testing

Tests for correlation between various factors are presented in the **Correlation Matrix, Table 4.8** This matrix shows only those combinations considered relevant or likely to have validity within the limitations of this study. For example no test was done to relate demographic factors to investment choice as it would be challenging to differentiate any trend specific to wind energy projects without including additional questions; over complicating the survey and introducing privacy issues. For these tests the bias scores used are weighted averages of the averages across all three turbine sizes from the weighted frequency counts in **Table 4.3** i.e. the overall average for each the three bias scores. This is justified on the basis that here general attitudes to the technology are being assessed against other factors of interest.

Table 4.8 Correlation coefficients							
Factor	Power	Owners	Domicile	Sex	Age	S/E Gp.	Invest.
Bias	0.97	0.24	-0.06	-0.05	-0.98	-0.99	0.41
Power	X	X	X	X	-0.17	0.04	0.06
Owners	X	X	X	X	-0.06	0.02	0.26

Correlations shown against green are NOT significant.
Those shown against yellow ARE significant.
See also **Figure 4.8** Path Analysis Chart, below.

For those factors scored by a dichotomous metric (domicile, sex and investment choice) the Point- Biserial Correlation Coefficient is used.(Lowry 2010). Pearson's is applied in all other cases. For this purpose the socio-economic groups are treated as a scalar variable with A+B scored as highest; resulting in a negative coefficient as bias score tends to negative as this metric rises. All t tests are treated as two tailed with an alpha value of 0.05. In reality the significances of the bias scores to power guess, age and S/E Group are much stronger ($P < 0.001$).

Interpretations.

The strongly significant correlation between bias score and power guess should not be taken as *evidence* of a causal relationship in any one direction. It is equally as plausible that someone hating turbines for aesthetic reasons tends to ignore evidence of their effectiveness, as it is for someone convinced of their poor utility to express negative bias. Compare this with the correlation scores for the power estimate factor in relation to age and to s/e group. For age, the power guess is significantly related, declining (under estimating) as age rises. However for s/e group; shown to be a significant indicator of bias, the power guess is not significantly related. One possible explanation of this is that across the population generally there is a fundamental lack of understanding of the scaling ratios of turbine size and potential performance, square law for rotor size, cube law for wind speed. All this has implications for the design and deployment of appropriate educational materials, including responses to critics of the technology.

The correlations of local ownership and investment choice to bias score go some way to confirming internal consistency among respondents, combining to indicate a mind set in favour of wind energy projects under local ownership to which they would be willing to commit investment. Interestingly, there is no significant correlation between power guess and investment choice; confirming that this choice is *not* based on unrealistic expectations of output, and hence revenue.

Figure 4.8 Path Analysis chart

4.9 Finding the extremists

This analysis is of unweighted survey returns. An examination of respondents scoring for extreme bias can tell us who the holders of the strongest views are, both pro and anti. This can be most easily accomplished using a visual tool, a demographic net. This type of chart allows a comparison between demographic composition of the sample with a range of possible selections from within it. Each radial arm represents a classification, the location on it a frequency from zero at centre (connective lines do not imply causal connections they are to provide visual clues to variations between different charts). The net for the sample, **Figure 4.9**, is included for comparison.

Figure 4.11 Large Turbines; strong objection vs. support.
As can be seen in the comparative shapes the biggest difference between these groups, apart from their size; is in age profile; supporters being a much younger group than objectors. Despite socio-economic group being indicative of attitude in the population it seems to make little difference in these sub groups. This suggests that for strongest opinions the main demographic indicator is generational and not related to economic or educational factors.

Figure 4.12 Opposition and support for Medium turbines.

This is the most balanced case of support versus opposition in terms of absolute numbers, but once again age can be seen as the dominating factor of difference between the two groups, with opposition heavily skewed to the two older groups representing over fiftys. Note also the spike in the direction of A+B in the S/E factor for supporters, in opponents this group is much less strongly present.

4.9 Potential investors

As mentioned above it would be rash to attempt to define a demographic breakdown of potential investors but this does not preclude trying count them. Taking the yes respondents to Q6 and then sorting them for positive or neutral scores to Q5 gives;

Table 4.9 Numbers of potential investors

Local Owners?	Neutral	Agree	Strongly Agree
Sample	129	125	27
Population*	37k	36k	7.7k

* Based on simply multiplying sample frequencies by sample ratio 143k/500

This indicates a potential pool of local investors numbering in their thousands, certainly encouraging for anyone proposing such a scheme.

Before summing up these results it is as well to be clear that the survey itself suffers from a number of possible sources of systematic error in the design, execution and analysis of data collected. Without performing follow up work it is impossible to determine quantitatively the impact on external and construct validity of the results.

i. The vast majority of data was collected by one worker; so any population bias against this demographic type would have affected response rates.
ii. A large proportion of people approached declined to answer the survey (roughly 5 to 1). This leaves considerable uncertainty as to validity of low neutral scores in the returns, as it may be argued that most of the population are not engaged with political issues sufficiently to respond, or even that they simply don't care, either would score neutral *if* they had responded. It is by no means clear that opinions collected in the survey *pre-existed* in the sample population, rather than crystalised at the point of contact as the issue was presented by the interview.
iii. Similarly, the all or nothing emphasis of question cues may have created a forced opinion; where previously the respondent had given the matter no mind. The very low number of neutral scores for the original questions supports this.
iv. The socio - economic breakdown of the economically inactive population may vary from that of actives recorded in the census data. This is especially important in the older half of the population showing greatest opposition scores to all sizes of wind projects (**Table 4.7**). Census data show an annual net immigration to Herefordshire of about 600 over 50's with the main origin being South East region (71%), notably Greater London and Surrey.(HCC 2010 (1)) Although banding non actives from the census data is not possible this strongly suggests that over 50 y.o. A and B groups are larger than the census of actives alone indicates (HCC 2010 (2)). On this basis the population cell weightings used may be flawed, demanding attention to the

strong likelihood that bias scores for the overall population will appear higher (more in favour) than they actually are.

Great care is needed in drawing inference from parametric testing of Likert-type scale returns (see Appendix **4**). However the results summarised below are considered robust enough to be used as predictors of likely responses to project proposals, especially at the extreme ends.

4.10 Summary

- The core question, is there a relationship between turbine size and attitudes to possible wind energy projects in Herefordshire is fully answered beyond reasonable doubt. (**Table 4.4**) In Herefordshire public attitudes move against WECS as they increase in size.
- The conditional supporter model proposed by Bell and others is confirmed by responses to the opposed questions cancelling out. (**Figure 4.4**. **Table 4.3**) Small turbines enjoy very high levels of unconditional support; large turbines attract twice as many opponents as supporters. Mid sized turbines have almost equal levels of support and opposition (**Table 4.5**).
- The previously reported demographic indicators of attitudes to wind projects (**Table 1.1**) are challenged in Herefordshire. The correlations and significance tests for attitude to age group and socio-economic band are sufficiently strong, despite methodological reservations, that these too are beyond reasonable doubt (**Table 4.8**). Unlike the surveys summarised in **Table 1.1**, in this county it is older and *better off* groups that are most opposed to wind schemes, younger and less well off groups are more supportive (**Figures 4.6 and 4.7**).
- The gender differences in **Table 1.1** were not found.
- The demographic nets for strongest opinions confirm high proportions of oldest groups in opponents but here the strongest supporters also include higher proportions of AB socio-economic groups (**Figures 4.9 to 4.12**). A balance is seen for medium size turbines between numbers of pro and anti responders.
- Herefordshire people have an inflated view of the performance of small wind turbines, overestimating by an order of magnitude; yet increasingly *under* estimate performance as size increases. (**Table 4.5**)This is seen to be strongly linked to bias scores,(**Table 4.8**) Only age is a significant demographic indicator for this variable, older people being more likely to underestimate output than younger.
- Bias score and responses to questions of ownership and investment choice show a sub group supportive of the technology, in favour of local ownership and ready to invest. **Figure 4.8** shows this group has no demographic boundaries with ownership as the dependant variable. This group shows no significant correlation to output guess; suggesting they have realistic expectations of such schemes. Combining yes respondents to the investment question with support responses for local ownership suggests thousands of potential investors (**Table 4.9**).

5 Performance, economics and turbine size

5.1 Performance issues arising with variation in turbine size.

This section examines if any differences exist between various sizes of turbine in terms of energy and financial returns on investment. As this is intended to compliment the opinion survey and resources are limited this necessarily relies on literature review or meta analysis papers. The limitations of each are explored at relevant points in the text and where possible anomalies are tested by first hand calculations based on primary sources. In addition to performance and payback data the objective behind this section is to identify common factors across sources indicative of any relationship between turbine size and both ROCE and EROEI; and if possible to discover sensitivity of these outputs to the critical factors.

How much energy does a wind turbine generate ?

To determine this requires actual performance data for a range of turbine sizes. The data gathered into **Table 5.1** and illustrated in **Figures 5.1** and 5.2 are derived from two websites, ecotricity.co.uk and goodenergygeneration.co.uk. The former mostly features projects at the larger scale, the latter a larger number, widely distributed across the UK, of a wider range of sizes. Not all projects on the websites are included; multiple sites in a small area at similar scale being passed over as redundant (see *count,* below). The websites offer the data as indicative and clearly state that it is based on average figures.

Table 5.1 Collected output data of different UK wind energy projects May 2010

Output of various sizes of WECS at onshore UK sites

Size (kW)	Count	Mean Energy (MWh/yr)	St.Dev. Energy	Mean C.F.	FiT (p/kWh)
0.5	2	1.65	2.19	0.38	34.5
1.5	1	0.5	0	0.04	
1.8	2	2.4	0.14	0.15	26.7
2	3	1.7	1.06	0.1	
2.4	2	1.5	0.99	0.07	
2.5	25	2.3	5	0.11	
2.8	1	2.9	0	0.12	
3	1	1.7	0	0.23	
4	1	0.1	0	0	
5	14	4.24	7.74	0.1	
5.1	1	10.3	0	0.23	
5.8	1	4.5	0	0.09	
6	39	6.96	5.61	0.13	
10	6	21.17	20.68	0.24	26.7
11	3	9.67	4.04	0.1	
15	7	19.14	12.12	0.15	

Table 5.1 Collected output data of different UK wind energy projects May 2010					
Output of various sizes of WECS at onshore UK sites					
20	2	22.65	17.89	0.13	24.1
30	1	70	0	0.27	
75	1	80	0	0.12	
225	2	316.5	249.61	0.16	18.8
400	2	1271.5	376.89	0.36	
500	1	1100	0	0.25	
575	1	192.5	0	0.04	9.4
600	3	1346	735	0.26	
675	1	667	0	0.11	
770	2	1277	1494	0.19	
800	3	2383	137	0.34	
850	2	1887	352	0.25	
1200	3	1250	491	0.12	
1300	2	1672	346	0.15	
1500	3	3065	1694	0.23	
1800	3	2990	1231	0.19	4.5
2000	5	4640	879	0.26	
2250	1	2315	0	0.12	
1325	1	1697	0	0.08	
2750	1	3352	0	0.14	

Size - here refers to nominal generator capacity in kW. This is no guarantee of the potential output of any given machine as developers may install equipment with a mismatched pairing of generator and rotor in order to give their products an apparently higher capacity factor. (Boccard 2009)

Count - refers to the number of sites from which data where taken, not number of turbines. This prevents an array of well sited highly performing turbines skewing the data favourably. As performance is dependant on available wind speed *and quality*; (Gwillim 2009); it is critically site specific. For the purpose of determining UK average performance it is best to examine output on a site by site basis. At the smaller scale almost all projects are single machine .

Mean and SD Power - in MWh/yr; are conventional tests of central tendency and spread in the data. Note these are of limited utility in the small sample sizes.

Mean Capacity Factor - is an industry standard expression of the difference between a WECS achieving rated maximum output at all times compared to actual output. It is calculated as

Reported output (kWh/yr)/ nominal rating (kW)x 8760 (h/yr)

It is dimensionless and often expressed as a percentage.

Feed in Tariff - in pence/kWh refers to the payment band as at May 2010. Data are grouped into relevant bands.

Figure 5.1 Small size turbine outputs

All data are as shown in Table 5.1 Where a data point has no spread it represents data from a single site. Note here that the higher threshold, 15 kW nominal, is the size of the smaller turbine used in the opinion survey. In all cases data and results of arithmetic operations have been rounded to aid clarity and to avoid the distraction of spurious precision which the raw data do not support.

Because of the very small sample sizes it would be wrong to draw too strong an inference about any one size of turbine, but in aggregate a number of things are evident. A larger turbine rating is no indicator of a larger output. Similarly, for a given turbine rating the range of outputs indicates extreme variations between best and worst performing. As output is critically site specific this suggests that some projects may well have been badly sited, may be on insufficiently high masts, or are otherwise inappropriate for the wind profile, perhaps unable to use wind at extreme (low *and*/*or* high) speeds.

Figure 5.2 Outputs of larger projects (All data from Table 5.1)

Similar comments about the averages apply to this graph. As may be expected the spreads are not as extreme as at smaller scales reflecting the greater care applied to project planning involving multi-million pound investments. The narrow spreads at the smaller end in this graph include records from projects over 15 years old and may well reflect the opportunity for early adopters to develop some of the best onshore wind energy potential. These machines are medium scale as defined in the opinion survey. Note that the middle section of the Table data are not represented on these graphs. Sizes between 15 kW and 100kW being too large at the small end and too small at the larger end even using logarithmic scales. Only three data sets representing 4 sites are lost to the graphic presentation, but are still employed in the aggregation (Table 5.2 below).

The range of source sites for this data aggregation reflects potential variation in sites available in Herefordshire for the range of different project sizes, with the obvious proviso that no coastal locations exist in the county. On this basis it is reasonable to take averages of outputs for specific sizes of turbines and overall capacity factors as similar site selection criteria can be expected to be employed. On the ground this means that smaller turbines will continue to be installed by mainly rural property owners and that commercial developers will seek to optimise their opportunities according to wind energy potential, access factors, and socio-political considerations.

Table 5.2 Averaged output and cash return 'Small, Medium and Large' Turbines.

Size (kW)	Mean Cap.Factor (SDev C.F)	Mean Output MWh/yr	FiT yield £/yr	Market yield 28.5.2010 (£34/MWh)*	Total yield Predicted year 1(£)
15	0.12 (0.06)	19.14	5110	651	5761
400-500	0.31 (0.08)	1214	288300	41300	329600
1800-2000	0.23 (0.05)	4021	181000	136700	317700
All	0.16 (0.09)				

* neta 2010

There is a severe risk associated with the high capacity factor suggested by this table for medium size machines as it is based on such a small sample. Any attempt to use it for financial projections is severely deprecated! It does however highlight that for some circumstances the financial returns of a medium size turbine may be comparable with that from a large one *despite producing significantly less energy*. Whilst it is understandable that pro wind energy advocates would want to highlight successful projects it may be harmful to the public and commercial perception of the industry if it appears to be making inflated performance claims. For example in evidence to the Parliamentary Economic Affairs Committee in 2008, Professor Michael Jefferson challenges the BWEA's claimed values for UK projects' capacity factors.

> *"of the 81 onshore wind energy developments operating in England throughout (2007) only 13.6% achieved a load {capacity} factor of 30% or over, the weighted average load factor was 24.42%"*

Jefferson 2008

Boccard offers this summary of average CFs at national level;

Boccard (2009) Table 2 p.2681

His data are taken from published information at national level rather than aggregating individual projects. In his conclusions Boccard emphasises the implications of erroneously high capacity factor projections not only in terms of project financing, but also in contribution to CO^2 emission reduction and energy security. He suggests that UK developers have tended to prefer onshore sites in less contested areas, over the expense and delay of fighting for consents in potentially more resource rich areas with high "amenity" values, leading to a lower than expected CF,

> *"it can even decrease with the large scale deployment of wind power into areas of medium quality. Notice that plenty of unexploited optimal sites remain available for future development."*

Boccard, 2009. pp 2683

In summary then, for small size and largest size turbine projects the performance averages indicated in **Table 5.2** may be taken as valid on an indicative basis. For the medium scale it is reasonable given the above evidence to downrate the CF to the same as the largest turbine size. From here on, this value will be used in output calculations for potential Herefordshire projects. The revised output line now reads as in **Table 5.3**.

Table 5.3 Medium size turbine performance (adjusted CF)					
Size (kW)	Adjusted Cap.Factor	Mean Output MWh/yr	FiT yield £/yr	Market yield 28.5.2010 (£34/MWh)*	Total yield Predicted year 1(£)
400-500	0.23	900	170000	30000	200000

5.2 How much does it cost to generate?

The economics of an energy technology are critically dependant on costs of capital equipment, operation and maintenance (O&M), decommissioning , financing and price received for energy produced. These will vary greatly across different technologies (Sims *et. al.* 2003) and for wind, between sites (Jefferson 2008, Blanco 2009). As the data above demonstrate the key indicator of performance is the capacity factor, seen to be site specific rather than hardware related.

As of May 2010 indicative pricing for 15 kW WECS, including civils and grid connections is of the order of £75k (Rensmart; Wells; Cooke. (2010)) This results in a headline figure of around **£5k per kW** installed nominal capacity. Turbines at this scale require a routine maintenance visit once a year, at an estimated cost of *" a few hundred pounds plus any parts"* with the main variable being travel of engineers according to S.Wade of Wind and Sun Ltd. (personal communication 1.6.2010) An assumed project life of twenty years is standard practice. Finance aside this scales lifetime varying costs at around 10% of capital costs.

Financial details for medium scale projects are harder to find, as this is no longer a common activity for developers and has not yet caught on at a local level. The Blanco paper (Blanco 2009) aggregated data from across the world mainly from industry organisations (such as European Wind Energy Association,EWEA) and governments as well as previous academic studies. She highlights the inherent methodological risks in this type of amalgamated data analysis; applicable here; that not all studies employ the same assumptions, standards or boundary conditions. Blanco's paper also tested for sensitivity of generation costs to the range of cost factors. It is beyond the reach of this study to undertake a forensic audit of her sources, and also pointless as she demonstrates any individual project economy will be most influenced by it's capacity factor. She arrives at a figure of 1100 -1400 €/kW (920-1235 £/kW at Q1 2010 average (exchange-rates.org 2010)) for new projects in Europe. This figure is purely the capital cost; she goes on to conduct a similar analysis of O&M and other variable costs subject to the same methodological reservations. Combining these two analyses permits a calculation of the cost of generated electricity. However Blanco identifies three sources of UK specific data which offer estimates of generated cost.

Table 5.4 UK Capital and generated power costs
(converted from original euro to GBP)

Source	Capital cost £/kW	Cost per kWh (pence)
UKERC 2007	n/a	5.2; stdev 2.2
DTI 2007a	1440 high wind 1631 low wind 1422	 9.3 10.1
DTI 2007b	n/a	7.1 - 14.0

(Blanco 2009 Table A1 p1381)

As the medium scale of project is comparable to the pioneering wind farm developments in the UK, historic data may safely be used at the high end to reflect possible present day project costs and cost of generated electricity (but see comments below on inflation). On this basis an installation cost of **1440 £/kW** can be taken from the DTI 2007 study along with an associated electricity cost of **10 p/kWh** for a medium scale (500 kW) project hypothetically undertaken in 2010.

At the larger scale of turbines, about 2MW rated generator capacity, Blanco's data yield an indicative cost of generated electricity of between 3.97 and 7.67 (mean 5.82) p/kWh. The variation is caused mostly by the range in real capacity factors between projects followed by differences in prices of fixed assets. Note that Boccard's table puts the UK second out of eighteen countries for average capacity factor, yet the UK specific data still show a higher cost of production than Blanco's global average. It is beyond this study to account for this anomaly but suggests at first blush that for some reason the UK experiences a relatively higher project capital cost than other territories. This matter may repay deeper examination.

5.5 Financial returns

The figures from the above sources can be assembled into an analysis of project costs and returns according to size. Return on capital employed (ROCE) is a commonly used statistic in company reports and is used here to ensure clarity between shareholder capital, possible capital grant and loan capital. Each would be used to finance a project in a proportion usually determined by a major lender and/or grant provider.

Table 5.5 Comparative net returns by turbine size				
Turbine Size	Capital Cost k£/kW	Generated cost £/MWh	Net £/ MWh	ROCE
Small 15 kW	5	196*	104	2.60%
Medium 500 kW	1.44	100	122	15.25%
Large 2 MW	1.24	58.2	20.8	3.40%

* Based on a straight line write down over 20 years.

It must be emphasised that these calculations are based on worst case assumptions, and are at all times critically and sensitively dependant on actual capacity factors. For the smallest turbines, usually a single property is involved and the financing could include some form of capital grant for a rural business which would massively improve the return for the developer. The availability of such grant funding is by no means assured. Similarly there may be an option to profit from displacing expensive consumer tariff electricity by using energy on site. For non business developers the siting options would almost always be bounded by an existing residential property, which may cause the range in capacity factors found at this size. At the largest scale apparent low return demands that a more sophisticated financial analysis is carried out, but note the issues raised below which may fudge this. In addition given the scale of investment the best available siting decision tools would have to be deployed, such as computer modelling of wind flows (VESTAS 2010) and wind monitoring and analysis prior to final siting. (Gwillim 2009)

Something needs to be said here on the matter of price inflation. In the early years of WECS development prices fell consistently year on year as the industry acquired skills and designs and processes followed classical learning curves.

> *"In the case of wind power, learning applies to turbine production, siting, connection to grid and {O&M}. The main gain ... ... is reduction in capital cost since capacity factor improvement is limited to better design of turbines and improved siting.*

(Boccard 2009 p2683)

According to Blanco (2009) this was followed by a period of a few years of rapid price inflation due to escalating demand both for WECS themselves and for core engineering materials. Clearly it would not be appropriate to model price movements on a general indicator such as retail price index (RPI), but safer to look to Blanco's own collected data for price over time. In addition, as this is a global market, cross currency fluctuations may impact spot pricing of components from different currency zones. As FiTs are inflation proofed for their lifetime, and the market price of supplied energy is determined by external factors, the impact of RTI movements on lifetime revenue is believed to result in a rise in cash terms. This factor will impact equally on all project scales so can be ignored in a preliminary comparative cost benefit analysis without detriment to the case. If anything the overall outcome will be a higher than expected return.

Similarly the issue of interest and discount rates ought to be included in any micro-economic project analysis. History shows both can be highly volatile in the short term and valid discount rates difficult to determine without sophisticated risk analysis. Blanco (2009) cites a number of studies into managing long term risk in fossil fuel generating and argues that wind should have a higher discount rate, reflecting long term stability of costs compared to use of diminishing fuel reserves. Conventional economic tools such as the Current Asset Pricing Model may themselves be challenged at a time when supposed risk free investments like sovereign debt are in reality found to carry risks (Q1 2010). These issues in reality are only relevant at the margins for any project which is not *primarily* intended to maximise investors' returns, as may be the case in a local community owned wind scheme, so long as the project actually produces a net return over time. Whilst a good return is important, the very existence of ethical investment funds shows investors may place higher personal value on such presumed benefits as contributing to climate change mitigation or reducing reliance on contested resources like oil. Government policy is certainly leading them in this direction at national level but an additional consideration being promoted by the "Transition" movement and the EST paper "Power in Numbers" (Baron et.al.2008) is *local* energy resilience (Fenderson 2006).

Finally this data allows a test of the relationship between capacity factor and ROCE; and also an examination of any putative relationship between turbine size and ROCE given the FiT thresholds. See **Fig 5.3** for confirmation of Blanco's findings that there is a critically dependant relationship between the economic viability of a project and the achievement of a respectable capacity factor. The graph of Return on Capital Employed (ROCE) against turbine size (**Fig 5.4**) reveals expected peaks at the boundaries of the FiT bands, demonstrating validity of the theoretical basis for the banding but also revealing a window of opportunity around the 500 kW size of turbine. Caution demands attention to the fact that the output data for this region of the graph is drawn from a small sample with an atypically high CF.

Figure 5.3 ROCE by capacity factor

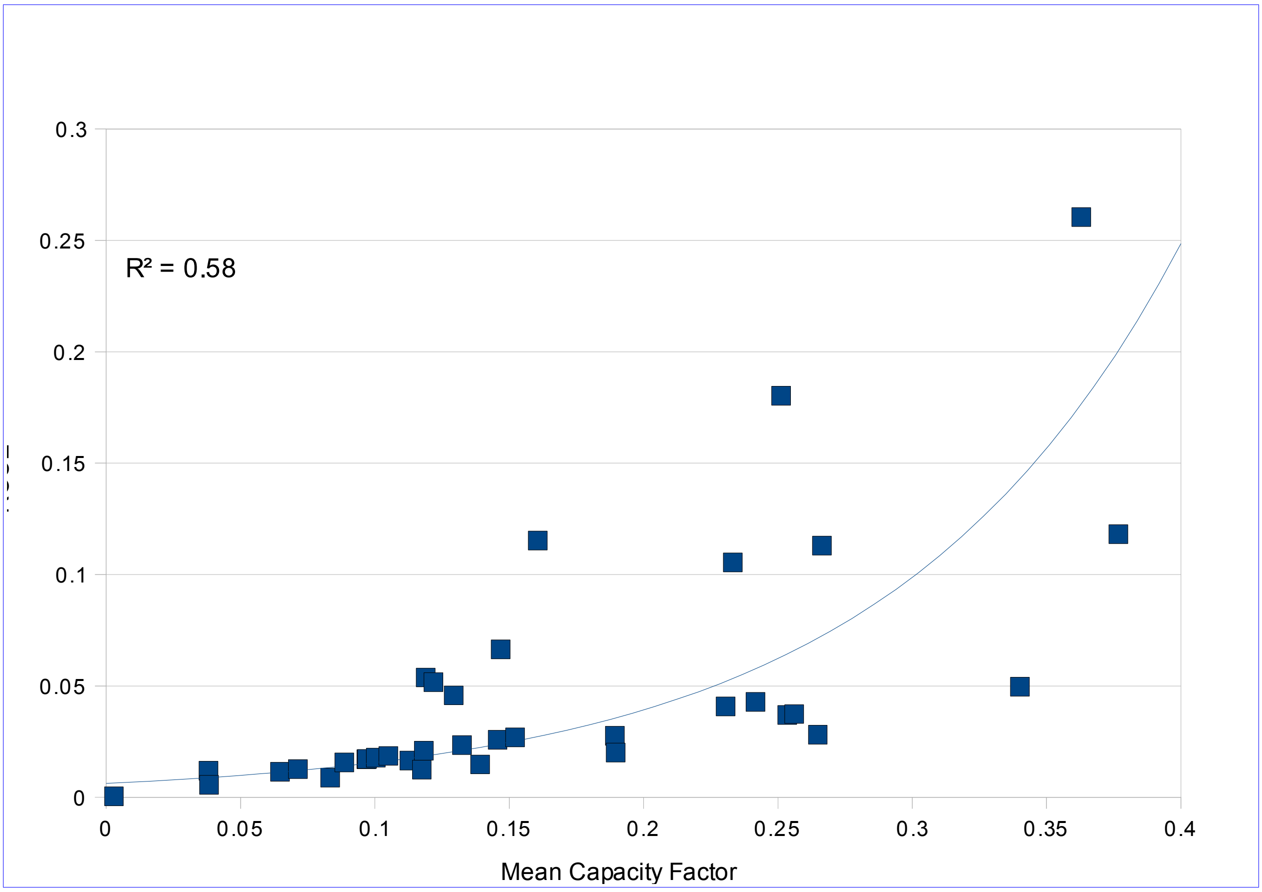
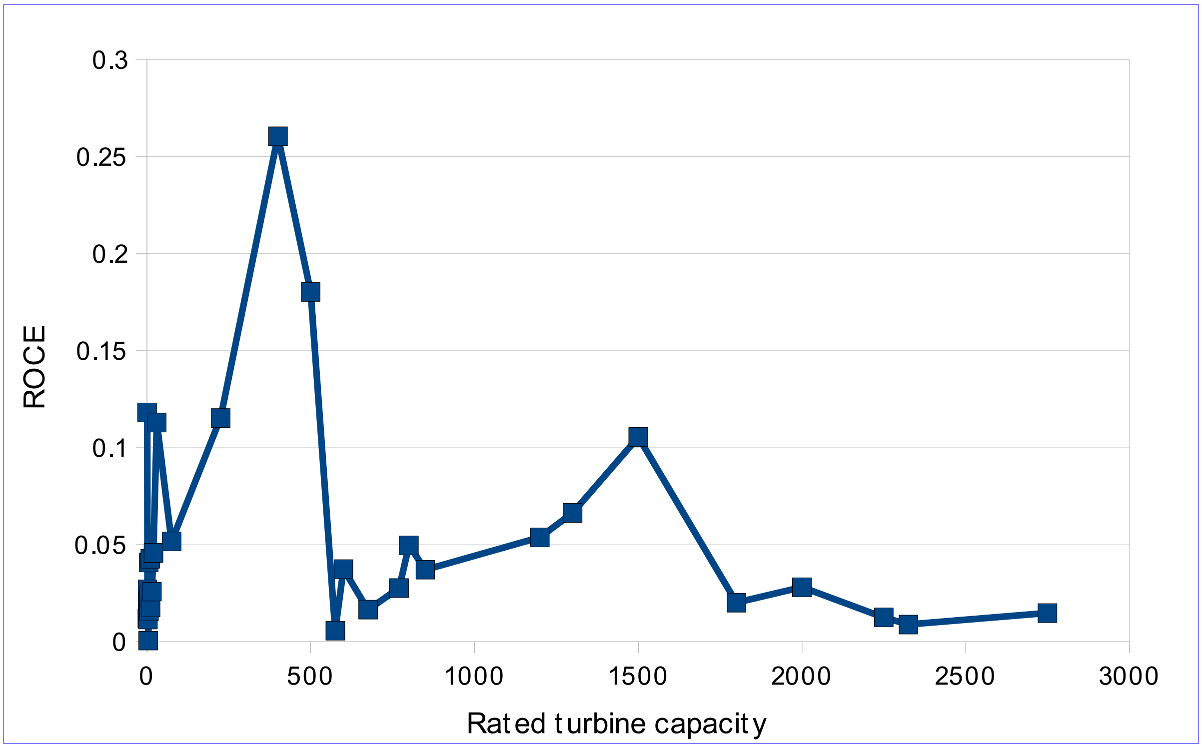


Figure 5.4 ROCE by turbine size



5.6 What about energy return on energy invested (EROEI)?

This section draws heavily from Kubiszewski and others (KUBISZEWSKI *et. al.* 2010). Their findings are used because they are derived from an extensive time period, 1977 to 2007, cover a large number of operational (60) and theoretical (54) project studies, the writers acknowledge the limitations of their work and they offer two useful models of relationships of EROEI to size of turbines. For the purposes of this study only the operational project data will be considered. (A web based search for additional peer reviewed sources failed to find material which was relevant *and* more recent *or* not included in this work.)The basic definition of energy return on energy investment is itself subject to debate but a good starting point is;

EROEI = cumulative energy produced/ cumulative primary energy required

Which Kubiszewski *et. al.* (ibid p218) expand to

> *"EROEI entails the comparison of the electricity generated to the amount of primary energy used in the manufacture, transport, construction, operation, decommissioning and other stages of the facility's life cycle."*

However this apparently inclusive list fails to mention the difference between electricity produced at the generator and electricity delivered to end users, in other words conversion and transmission losses. Nowhere is this more important than the case of wind energy where effective projects may be distributed across undeveloped areas remote from the majority of end users. It is vital for local resilience models for example to consider the impact distributed small to medium sized generators could have on the overall level of these losses, but at present the UK grid lacks the sophistication to exploit this potential. It is a work in progress (ENSG 2009).

Figure 5.5 Input/Output of a generating facility (Kubiszewski *et. al.* 2010 fig 2 p 219.)

In this graph EROEI is the ratio of cumulative total above the x axis to total below it. Note that if transmission and conversion losses are included in the self-use category the previous objection is redundant.

The paper creditably also makes reference to externalities such as environmental and human costs which are hard to quantify in economic or energy terms but does not attempt to include these in the analysis. The authors also draw attention to two principal methodologies of analysis, process analysis and input-output method, and also a hybrid combination of the two. The values for EROEI using the former are about double those using the latter (24 vs.12). As in the economic and financial analysis the most critical factor effecting EROEI is the sum of energy produced; quantified for comparison as the capacity factor. The principal finding of their analysis is that EROEI for operational plant studied is average 19.8 (n-60; s.dev. 13.7). However their graph of size comparisons is much more pertinent to this study (Figure 5.6)

Figure 5.6 EROEI in relation to power rating (Kubiszewski *et. al.* 2010.fig.3 p224)

For reasons not made clear the authors do not include turbines above 1 MW rating "*due to lack of reliable data"*. However their tabulated data includes such (operational) projects with a wide range of CF and EROEI, suggesting that it includes experimental (from the 1980's) as well as production equipment and that boundaries and methods of source papers are inconsistent. **Figure 5.6** does give values for the small and medium scale turbines of specific interest to this study; leaving a value for a 2 MW project to be determined. At first blush the value could be estimated sensibly by extrapolating the curve of the plot in **fig. 5.6** and suggesting an indicative value of 30 - 35. In contrast to this a desk study using input/output method by a student group at UEL/CAT(including this writer) based on published information for ancillary works to the Reeves Hill development (ukplanning.com 2010) and manufacturers data for a 3MW turbine (Vestas 2010) and mast assembly found an EROEI value of 17. To summarise for the three sizes of turbine;

Table 5.5 Typical EROEI for three scales of turbine		
Turbine rating kW	Range	Average
15	5.15* - 8.3	6.7
500	15-30	20
2000	*17* - 35*	*26*

* Values from CAT desk study. All others from Kubiszewski et. al.

It is most clear that there is a positive relationship between turbine size and EROEI. A suggestion that it may approach a limit value (from the shape of the plotted curve in **Figure 5.6**) would demand deeper investigation with more up to date data for large on shore projects. Finally, the authors offer a graph showing the relationship between EROEI and dimensions of WECS.(Reproduced here as Figure 5.8)

Figure 5.8 Rotor size to EROEI (Kubiszewski *et. al.* ibid. fig.4 p224)

This is consistent with expectation based on known physical relationships between power available and both rotor swept area and rising wind speed at increasing height above ground. (Gwillim 2009) However as a basis for a policy argument it is challenged by the wide spreads in data from actual projects. It is to be hoped better siting decision tools (eg. computer modelling) will make an impact on this for current and future schemes.

5.7 Are there any viable sites in Herefordshire anyway?

The physical factors which determine suitability of a site for a project are available wind resource, access to the site for components (notably blades) and construction equipment (large cranes), and proximity to grid connections with sufficient capacity. According to one consultant a site search found no suitable locations in Herefordshire (Heal 2009) in 2005 with inadequate access roads being the principal barrier. The fact of the Reeves Hill development suggests that opinions on any of these factors may vary, and that viability may be variable according to changes in external factors, most notably changes in the UK support mechanism, but also possibly improvement in turbine outputs and siting decision tools.

Referring to **Figure 5.9**; this map is derived from a very course grained (1 km square) computer model stated to be indicative only (Rensmart/NOABL database/2010b). Despite this it clearly shows potential sites to explore with a predicted average wind speed in the 7m/s region considered minimum for commercial projects. However by their very nature as higher altitude locations there are bound to be a number of contentions and practical difficulties arising from their proposed utilisation for WECS.

The county of Herefordshire "enjoys" the legacy of two historical geographical forces which mitigate against larger scale wind energy projects. Firstly the landscape is classed as 'ancient' in Rackham's definition (Rackham 1986), made up of irregular shaped enclosures, winding rather than straight roads, replete with old hedgerows and small woods with wildlife to match. Consequently, in addition to statutory protected areas like the Wye Valley Area of Outstanding Natural Beauty (WVAONB) there is a locally defined category of protected landscape where there is a presumption against development in local plans; (but this has no legal force against national policies). Also much high ground to the south and west of the county is visible from the Brecon Beacons National Park (BBNP) with similar geomorphology. Remaining high ground is mainly modern forestry plantations and upland grazing to the north and west, mixed farmland in the north east, semi natural ancient woodland east of the city (AONB), and mixed farmland to the south. Possible access routes onto higher ground are likely to present obstacles to road movement of large cranes and turbine components, as is the case with the Reeves Hill project, demanding considerable civil works to highways prior to turbine installation.

Figure 5.9 Wind map of Herefordshire (Rensmart/NOABL database/2010b

The second historical force is the settlement pattern. From Iron Age people whose legacy of a ditched enclosure on every major hilltop; now Scheduled Ancient Monuments; to the distributed defence in depth adopted by the Saxons to protect against incursions from the west the resulting pattern of dwelling places is one of wide dispersal. It is said that unless in the heart of a wood there is nowhere in the county from where one cannot see a dwelling. For siting a WECS this challenges the need to avoid proximity to houses, due to potential noise impacts. Industry practice is based on the policy document ETSU -R -97 which has now become severely contested due to it's age and the growth in physical size of turbines for onshore sites in the intervening years. Handfuls of multi-MW turbines located over a few square km give rise to acoustic phenomena never before found in nature and appear to be causing previously unseen psychoacoustic effects on nearby residents. (Hayes Mckenzie 2006, Pierpont 2009). However by 2006 only 5 UK sites had associated reports of issues and personal accounts of a very small number of alleged victims recur throughout the wind farm opposition literature; including a letter of objection to Reeves Hill. (ukplanning.com; 2010). The rule of thumb to avoid siting a major turbine within one kilometre of any dwelling would demand each potential site to be centred on a 1km radius empty of dwellings, a severe challenge in the county as a glance at the OS Landranger map demonstrates.

There is a high level (400kV) grid transmission line across the southern tip of the county . As of spring 2010 there are rumoured plans by National Grid to bring a new high voltage connection from central Wales to connect with this, but no exact route is yet published, nor is any mention made of this line in the Electricity Networks Strategy Group (ENSG) report for DECC in March 2009 (ENSG 2009). The remainder of the county is served by 133kV lines or smaller. (La Tene Maps 2005). No information has been sought as to available capacity in these lines for export of surplus power. In addition, no enquiry has been made in this study into pricing grid connections that would be required by medium and large size turbines outside of the general inclusion in project costing in Blanco's paper (2009).

5.8 Summary

- The collected data from this broad range of typical project scales all demonstrate that for both energy output and economic performance, the most critical variable is capacity factor, which is related to site conditions.
- The collected data in **Figure 5.1** clearly show a wide range in performance of projects at the smaller end, suggesting poor siting decisions, leading to poor capacity factor.
- For financial return the *next* most critical factor is rated turbine capacity and how it relates to FiT boundaries (**Figure 5.4**) with a profitability spike at 500 kW.
- Real project financing will be strongly impacted by any capital grants being available; not included in these calculations as they are vulnerable to political fashions (and at present ruled out by FiTs conditions) Similarly the use of on site electricity to displace expensive grid power also adds to the financial benefits.
- For energy there is no question that larger turbines give better net gains (**Figure 5.6 and Table 5.5).** It is also clear that large numbers of small turbines replacing the output of a single large one is severely challenged by this measure.
- EROEI improves with size much more quickly at the small to medium range.
- Only a very small number of potential sites in the county have modelled average windspeeds of 7m/s at 10m, they are all likely to be contested locations.
- Grid capacity may be limited locally, but this may change in the near term with grid modernisation.

6 Discussion

6.1 This chapter explores the survey results and the outcomes of economic and energy assessments in the context of both county and wider energy policy debates. It begins with the technical matters and fits these into the original question and options available to the county population. The survey results are then considered in the light of this analysis, and possible policy consequences explored.

6.2 Implications of the EROEI and ROCE analysis for meeting local needs.

For Gunn-Wilkinson's (Gunn-Wilkinson 2009 and **Appendix 1**) assertion that the county should not have further large turbine projects but should instead look to '*a range of intermediate technologies to fit different needs*' the test would be what such needs in fact are, and what scales of technology can meet them? In 2008 electricity used in the county was as shown in **Table 6.1**

Table 6.1 Grid Electricity use in Herefordshire 2008			
User type	**Supplied GWh**	**No.Meters**	**Mean/meter**
Domestic	387.8	79, 700	4, 867 kWh
Industrial and commercial	617.5	10, 100	61,433 kWh
All	*1005.3*	*89, 700*	

(DECC 2010b)

To meet the government's (now lapsed) target of 20% of electricity from renewables in the order of 200 GWh of renewable sourced electricity is needed to meet the existing load in the county. The number of turbines at different scales required to meet this is shown in **Table 6.2** All data used are from tables in section 5.

Table 6.2 Number of turbines and capital to meet 20% of 2008 consumption			
Size	**Mean output/yr**	**No. Required**	**Capital cost**
Small	19 MWh	10, 500	789.5 M£
Medium	900 MWh	222	167 M£
Large	4000	50	124 M£

To sense what would be needed to supply all the county demand from wind alone, scale up these figures by a factor of five as an indicator of cumulative electricity need, without considering the peak power demand or intermittency issues. In addition this only covers electricity; energy used as liquid fuels in transport and agriculture is not included, nor is gas or solid heating fuels. Clearly this shows the absurdity of considering energy policy on such a limited local basis; that the county already displaces any social and environmental costs of it's energy supply to other areas and that for the county to address even the modest 20% target by local projects would appear to require all the identified suitable locations; regardless of contentions (**Figure 5.9** Wind Map; and comments to it)

Even on a local level however some contrasts can be seen between the options available to the rural property owner able to finance a small WECS and profit from FiTs, and the city social or private tenant hooked onto the grid supply. Unless a policy addresses the needs of the latter it must be regarded as unsustainable in social justice terms (Chambers *et. al.* 2000) Similarly, the energy needs of the county urban poor cannot be met at the expense of environmental and social degradation elsewhere whilst claiming to be sustainable. 'Elsewhere' in this context includes the future (Illich 1974, Meadows *et. al.* 2005). These basic calculations challenge the underlying supply side assumption that electricity production and use can, will, or should continue at current levels. (Illich op. cit.)There are other potentially sustainable energy options pertinent to the county, notably biomass, and the possibility to deploy it in a joined up way through community combined heat and power plant in the densely developed areas. Adoption of such techniques would inevitably result in significant land use changes, especially in areas marginal for modern agriculture. This would have impacts in the visual landscape, as well as on wildlife (some of which may well be beneficial; (ADAS/CALU 2008)). No single technology is immune from contention.

The data in **Table 6.2** demonstrate that if energy production at lowest cash and energy cost is the *only* consideration, then Herefordshire's few hilltop sites with higher average windspeeds ought to be developed with large turbines at optimum density, to be decided by site specific monitoring and modelling to achieve best possible Capacity Factors.

The suggestion that large turbines should be sited on industrial areas is challenged by supposed lack of suitable resource, ie low wind speeds. Some developers have done this with mutli- megawatt turbines in semi-urban locations, such as Green Park Reading (**Figure 6.1**) where a 2 MW rated device yields 3.5 GWh/yr, on a site with a modelled average wind speed of 4.6 m/s (ecotricity 2010 and NOABL wind map (rensmart 2010)) a CF of 20%. If such a CF is achievable in apparently low resource areas it opens up much larger areas of the county as potential sites. Another potential bonus of siting large turbines in industrial zones is partial elimination of conversion and transmission losses, such as Michelin Tyres in Dundee (ecotricity 2010) where two 2MW turbines with a combined CF just below 23% (despite being a coastal location); supply power directly to process plant. The two thirds of county electricity use in the Industrial/ commercial sector demands attention. Despite the poor CF, being able to displace bought -in grid power gives additional financial bonus in reduced costs; an advantage not available to developers solely supplying into the grid from remote hill top sites. However a radically divergent view is offered by Professor Jefferson, (Jefferson 2008(2)) insisting that deployment of WECS at sites yielding relatively low CF is wasteful of the capital resources; instead arguing that they must always be deployed at optimum sites. Whilst there may economic merit in this, it fails to consider the local use benefits and overall social benefits possible from a busy WECS manufacturing industry. An interesting policy exercise might be to attempt to set an EROEI threshold *below* which a project can be considered wasteful in the wider social context.

To propose arrays of small (eg.15 kW) turbines on sites with good wind resource is revealed as nonsense, both in terms of capital required and EROEI. The sheer numbers needed would overcome the only advantage such schemes would offer, the supposed lack of contention in the planning process (Proven 2010). Deployment of small turbines in urban areas is challenged by the need to avoid turbulent wind areas, the wide range of outputs and CF in **Figure 5.1** and **Table 5.1** for small machines demonstrates their vulnerability to poor siting decisions (Rhodes 2008). Such decisions continue to be made by developers for whom energy and cash returns are not the primary concern, such as a project at the new Minster College in Leominster (**Figure 6.2**)

Figure 6.1 Green Park Reading 2 MW turbine

(Andy Smith copyright. Google Image Licensed under Creative Commons License)

Figure 6.2 Vertical Axis WECS at Minster College.

(Photograph P.Linnell 2010)

That the sellers (Quietrevolution 2009) claim this turbine is suited to built environment locations does not make it immune from performance losses from turbulent wind flow, or justify it's location so close to zones of turbulence around vertices of the adjacent building. It remains to be seen how it performs.

The potential of siting medium scale turbines, (rated power 400 to 500 kW on a mast height of about 40m) in urban and/or industrial land is hard to assess as no specific examples could be found. Siting decisions would demand careful modelling to avoid zones of turbulence, and steps taken to prevent encroachment by surrounding development for the life of the project; both challenging. The only plausible reasons for developing such turbines are to take advantage of the ROCE spike at the 500kW capacity FiT threshold, (**Figure 5.4**) or to overcome *conditional objections* to larger scale schemes at the same site. If it can be demonstrated (a working example would help) that WECS at this scale are still large enough to overcome turbulence issues associated with surface roughing features such as buildings or trees (Gwillim 2009) and that modelled average wind speeds as low as 4 to 5 m/s are indicative of possible sites giving a CF of 20 to 23 % at 40m hub height then many possible sites exist within a few kilometres of the city centre, as well as around the market towns. (**Figure 5.9**). No such sites are more than a kilometre from the nearest dwelling, but all are sufficiently close to other noise producing activities to reduce the possible impact of cumulative turbine noise.

6.2 How would the people of Herefordshire react to widespread WECS developments?

The opinion survey was an attempt to address this question in terms of attitudes to different size turbines, and to discover demographic indicator variables for strong supporters and opponents. As detailed in Chapter **4 Results** the survey itself suffers from a number of possible sources of systematic error in the design, execution and analysis of data collected.

The two opposed policy statements used to elicit responses indicate a high level of the conditional or qualified support suggested by Bell and others (Bell *et. al.* 2005). By rejecting the proposal that " *these {turbines} should be allowed anywhere they will work*", and also rejecting the proposal that "*Herefordshire should not allow these anywhere in the county* the respondents have logically agreed that there *must* be locations in the county where they *could* go. This then leads to the more contested matter of *where*, under what *conditions* and *who decides*. By co-locating the boundary of the arena for discussion with the familiar administrative county, proximity effects may be assumed to be present.

From matters discussed in the Introduction from earlier survey work, the summary of results (**4.10**) compares Herefordshire with the more general case from **Table 1.1** and shows an unexpected anti-wind bias among advantaged socio-economic groups compared to less well off. This may well be related to numbers of immigrants both in this S/E group and at or near retirement age, and whatever expectation they bring of the county economy, landscape, development. etc. An industry has grown around selling Herefordshire houses from London agencies to down sizing or lifestyle choice buyers, see for example relocateherefordshire.co.uk or *Hereford Times* property pages any week. It is not possible from data at hand to determine the impact this specific group had on the survey results, but it suggests further more detailed work would be revealing. For older well off people to oppose renewable energy in the county is a direct denial of energy equity, but is to be expected perhaps in a generation raised in a world of abundant cheap hydrocarbon fuels, and no concept of consequences arising from their profligate use. For pensioners dependant on yields from investments as annuity or direct shareholdings there may be little choice in the manner in which their capital is used in a global market, but this is no excuse to not find out and address the ethical issues this may raise (Mollison 1990) It is not enough to shop at the Farmers' Market to support local food producers if the money spent is earned by capital doing social and environmental damage in another part of the world. As long as annuity providers favour defensive holdings such as utilities a paradox exists where pensioners can both profit from wind farm developments by transnational utility companies and simultaneously oppose new projects.

There is no doubt any proposal at any scale coming to the attention of that small group (9 in 500) who are strongly against *all* sizes of WECS in the county would trigger opposition. That rising numbers of small scale projects (eg schools, and also 7Y Energy, (Wells 2010)) are being installed without contention suggests that on a one off localised level opposition fails to materialise or if it does it fails to carry sufficient weight to influence the planning process. For projects at larger scales the experience of the Reeves Hill scheme clearly shows even a small number of well resourced people can have an overwhelming impact on the planning process. As van der Horst and Toke put it;

> *We are far removed from a situation where all sections of society have the same level of efficacy, agency, financial, human and social capital to affect the outcomes of local to national political process.*

(van der Horst& Toke 2010 p215)

6.3 Contention issues.

By opposing an application for their own good reasons a small highly motivated group can create public facing opposition groups able to generate or attract additional support from less committed neighbours, such as writing letters to committee members. In the discourse model of the UK planning system proposed in **Table 1.2** such groups are using a conceptual framework which is adversarial and conflictual facing the developer and public policy, whilst being consensual internally and in relation to other opposition groups. The centralisation of sources of information and campaign materials through Country Guardian tends to reinforce the group consensus across hundreds of small local groups. It seems likely that such groups see themselves as in conflict not only with developers and national planning policies but also with their local agents, the officers and members handling applications. Aitken (Aitken 2010) emphasises the importance of trust in public participants and the knowledge they bring to the process. It is hard to reconcile this view with campaign materials offered through Country Guardian and the Foucauldian model of adversarial discourses in the planning system (Stevenson 2009, Flyvberg 1998 and above **Table 1.2**).

Haggett and Toke (2006) have used discourse analysis of opponents materials and found that they present themselves as strongly 'environmental'; giving rise to so-called 'green on green' conflicts between landscape conservationists and renewable energy advocates. The language of landscape protection suggests that WECS 'damage' important historic sites, views and contexts.(responses to Reeves Hill planning application, and elsewhere; see above **1.3**) In contrast it can be said that this 'damage' is a construct of the perceived salience of the existing 'value' to the onlooker.

In the case of psycho-acoustic effects considerable work remains to be done to clarify causal effects in the small number of existing cases,(Hayes McKenzie 2006, Pierpont 2009), yet this remains a powerful issue of contention for opponents to impact development processes (J. Halle, Energy4All, personal communication May 2010). It remains to be seen how relevant such objections are in urban and semi-urban locations where noise levels may be expected to be higher.

Arguments based on NIMBY attributes, such as threat of falling property values, are mentioned without being emphasised. It must be noted that these arguments are not likely to be relevant to pensioners in city social housing. For those likely to feel affected there are counter arguments such as reports showing no effect on house prices close to wind farms in Cornwall (Sims,S. et.al. 2008). This could be used to create contention in sub-urban or semi rural locations proposed as sites for medium and large turbines, especially as properties in such areas tend to be higher value to begin with. Whilst the survey found no significant difference between urban and rural dwellers' attitudes (**Table 4.7**) other indicator variables may be more relevant in these locations, notably socio-economic group.

6.4 Consultation and participation

It is axiomatic in the UK that 'the public' are allowed to respond to planning applications by making written submissions of support or opposition, or by personal contact with decision makers. How much notice is taken of such responses is unclear, especially in an age when organised supporters or opponents can easily generate form letters from hundreds or even thousands of individuals. In the wider context of environmental equity and sustainability the United Nations Environment Programme lists five components of participation;

> *1. Identification of the groups/ individuals interested in or affected by the proposed development;*
> *2. Provision of accurate, understandable, pertinent and timely information;*
> *3. Dialogue between those responsible for the decisions and those affected by them;*
> *4. Assimilation of what 'the public' say in the decision; and*
> *5.Feedback about actions taken and how the public influenced the decision.*

(Clark 1994 quoted by Glasson *et. al.* 2005 p 159)

Quite apart from methodological difficulties in identifying stakeholders at all, this whole process appears grounded in the Habermasian consensual model of civil society in which contended matters are resolved through an evidence based dialogue(Stevenson 2009, Flyvberg 1998). For the people or groups who experience society as a power struggle this may be seen as having to yield vital information and space, or time, to the adversary; delaying what may be perceived as vital and urgent renewable energy developments. Never the less, in the UK at present there are minimum standards of information required in any planning application; appropriate to project scale, placing considerable additional burdens on any new community group projects.

Glasson *et. al.* (op. cit.) offer a summary of public participation methods and their relative effectiveness, Table 6.3 below ,derived from Westman (Westman 1985)

Table 6.3 Methods of public participation and their effectiveness				
Method	**Inform**	**Inclusiveness of interests**	**2 way communication**	**Impact decision making**
Explanatory meeting, presentation	**+**	½	½	
Small group presentation	**+**	**+**	**+**	½
Public exhibit/models	**+**	**-**	**-**	**-**
Press release, legal notice	½	**-**	**-**	**-**
Written comment	**-**	½	½	½
Poll	½	**-**	**+**	**+**
Field Office	**+**	+	½	**-**
Site visit	**+**	**+**	**-**	**-**
Advisory committee. Task Force, community representative	½	½	**+**	**+**
Working group of key actors	**+**	½	**+**	**+**
Citizen review board	½	½	**+**	**+**
Public enquiry	**+**	½	½	**+/-**
Litigation	½	**-**	½	**+/-**
Demonstration/Riot	**-**	**-**	½	**+/-**

For all it's apparent inclusiveness, this table indicates a world view of a developer led, rather than a population needs led, style of development, it very much shows a view that development is something which is done around or to an impacted population. Failure to include methods such as participatory appraisal which would give an impacted community the opportunity to challenge how a development would meet their own needs (White & Taket 1997) and opportunities to reject or to take ownership of it; demonstrates top down and supply side thinking (Walker *et. al.* 2007, Illich 1974). Szarka concludes (Szarka 2004 pp 328)

"...social acceptance or rejection of wind power is not just a 'story line' about

subjective or aesthetic reactions to large turbines in the landscape. At the heart of the debate is the question of meaningful choice over alternative development pathways, as well as lucidity over their consequences."

6.4 Inverting the argument; something that could enjoy support.?

Looking at this tool box again from the view of a community itself being the developer, and supposing that opposition comes from a combination of a small high powered group within (**Figure 4.11** and **4.12**) and similarly effective outsider stakeholders; as has been the case in Reeves Hill and other contested sites in the UK to date, it still fails to offer anything shown to be entirely effective in resolving predictable contentions. It does however suggest methods by which larger numbers of owner/participants can be found within the community. Whilst overall returns from the survey indicate both age and socio-economic group are indicator variables for likely opposition, the demographic nets show strongest supporters also include people in the most advantaged groups, but in the younger age bands (**Figure 4.12**). It must be from this group that organisation and development of community owned wind projects is most easily, but not necessarily exclusively, enabled.

The survey included basic, exploratory questions on ownership and investment; which yielded results showing a small increase of support for locally owned projects. There is a strong correlation (**Figure 4.8**) between positive responses to this and yes response to the investment question. **Table 4.9** suggests that potential investors in the county number in the thousands but much more detailed work is required to establish likely numbers and possible amount of total investment. Perhaps the greatest challenge raised by these questions is hinted at by informal qualitative responses from interview subjects, generally lacking awareness of community ownership models , along with concern that this *could* mean involvement of the local authority. This is indicative of a skills deficit in developing communitarian solutions to infrastructure problems, also found in other renewable energy projects (Linnell 2009) in contrast to the experience of Germany and Denmark (Agterbosch *et. al.* 2004). But experience elsewhere in the UK gives hope that locally owned medium and large scale wind energy projects are achievable.(Warren & McFadyen 2010, Devine-Wright *et. al.* 2007, ecotricity 2010).

7 Conclusions

7.1 This work set out to investigate the question "Are smaller turbines the way forward for wind energy in Herefordshire?" The opinion survey has shown that although smaller turbines do enjoy more support, there remain a small number who are likely to oppose them (**Figure 4.4**) It is reasonable to suggest that if the many thousands of these required to make a difference in the wider context (**Table 6.2**) were to be installed across the county latent opposition would become manifest. In this sense the proposal by Proven for 'Windcrofting' (Proven 2010) is revealed as nonsense. However, there are many people for whom the county should find some locations for the largest turbines (**Figure4.2**), leaving questions of where, under what conditions, and who decides. In the middle ground, roughly equal numbers support and oppose the local siting of the medium scale turbines suggested by Gunn-Wilkinson(2009)(**Table 4.3**).

7.2 Whilst in pure energy economics terms the largest WECS give the best return, the improvement with scale levels off as size increases; making medium scale WECS much more effective than small ones, but the largest not much improvement over the middle scale (**Figure 5.6**) Because of the thresholds and payment levels of the FiT scheme there is a sweet spot in project size at 400 to 500 kW at which ROCE is maximised (**Figure 5.4**).

7.3 It may be suitable for a small number of 'well off techies' (WoTs- as coined by Harper 2008) to invest in a small WECS and believe they are reducing their climate impact whilst profiting from FiTs; but this view is challenged by two criticisms. Firstly it does nothing for the energy needs of the vast majority of the county population who do not enjoy ownership of a suitable property, their needs for energy can only be sustainably met by demand reduction and/or larger scale WECS and other appropriate technologies (**Table 6.2**) . Secondly, is this the best use of capital and taxpayer support? The relatively high FiT level for small scale WECS is challenged as a viable use of tax money for carbon emission reduction. It is well known that the 'low hanging fruit' of energy saving is simple DIY level draught proofing and insulation in all except the most modern houses (EST 2010 Boardman*et. al.*2005). This matter demands further examination, not least as a critique of micro- generation with taxpayer subsidy. Money spent on quality energy saving measures keeps carbon emissions down for the life of the building, whereas rewarding production alone may encourage wasteful use.

7.4 Without doubt, project capital cost per kW installed capacity falls radically between small and medium scale WECS (**Table 5.5**) so to seriously impact renewable energy targets capital is most effectively employed at the medium and large scale (Jefferson2008(2)). As seen above, medium scale projects are best for ROCE yet are large enough to supply the equivalent annual use of a few hundred households. This would appear to make them ideal for village scale community owned projects. A further possibility not examined thus far is deployment of electric cars (Hodge et.al. 2010). By displacing costly hydrocarbon liquid fuels a village WECS feeding in to dozens of battery cars would enable rural dwellers to maintain affordable contact with town based services whilst reducing carbon impact. This would repay further detailed study, along with it's implications for grid stability and intermittency.

7.5 Two thirds of all electricity used in the county goes to the industrial and commercial sector (**Table 6.1**). Further detailed study may yield suitable locations in industrial zones where WECS can be sited next to large users; removing grid loss and making lower CFs acceptable; as is the case at Dundee (ecotricity 2010). This is also a sector which should examine it's potential for demand reduction; not least as a cost saving measure.

7.6 The most likely source of opposition to wind projects are older well off people (**Figure 4.10**). Only a more detailed study would reveal if these are natives or parvenus making this a significantly different result from previous studies elsewhere (cf **Table 1.1**); but they are likely to be best equipped to raise opposition to any project not to their liking (van der Horst & Toke 2010). Opponents to wind farm projects across the UK share a common set of concepts and materials which have been deployed locally against the Reeves HIll development (Country Guardian 2010 and ukplanning.com 2010), there is every reason to suppose that any new large scale scheme would be similarly contended. By every indicator of likely planning dispute, Herefordshire is a high scoring county (van der Horst & Toke 2010).

7.7 In the last decade there have been a number of government initiatives intended to support and encourage communities to set up their own local renewable energy schemes (Walker *et. al.*2007). The failure of these schemes to deliver widespread significant results on the ground demands further study. A first blush examination of Clear Skies and Low Carbon Buildings schemes shows them massively over subscribed and placing high demands on applicants; not encouraging to new community groups. The greatest barrier to community WECS projects appears to be lack of community capacity to act together. In this new age of politics with it's language of "Big Society" and local solutions perhaps the time is now come to initiate more capacity building for project development at village and estate level.

7.8 That the strongest supporters of medium scale WECS in the county include 30 to 50 year olds in the most advantaged groups (**Figure 4.11**); and that there may well be thousands ready to invest (**Table 4.9**) are both strongly suggestive that both the individual skills and adequate seed money exist locally to begin projects at the medium scale, if not larger. They just need joining up.

7.9 Finally, in the long term, only demand reduction is likely to produce a sustainable solution to equity in energy availability (Illich 1974, Mollison 1990, Kemp *et. al.*2010). Herefordshire may now be a desirable location to escape the pressures or consequences of a highly materialised technological economy; but it is also a favourable location for those attempting to create genuinely sustainable and equitable ways of life through new intentional communities and low impact developments. It remains to be seen how far either of these cohorts are willing or able to support projects which meet basic needs of the less fortunate, not only in major urban areas, but in the heart of the county itself.

APPENDIX 1
Letter as published in the Hereford Times August 20th 2009

"Small - scale schemes are a better way to get electricity"

In the Hereford Times (July23) you published an article which aired the concerns of the Friends of the Golden Valley campaign group about the potential development of large wind energy schemes in the county.

The Golden Valley Environment Group, with 120 members from Eywas Harold to Hay-on-Wye - shares their concern that the cumulative impact of very large schemes would dominate views of the Golden Valley and the Black Mountains.

These are areas of high landscape value and are particularly sensitive to new developments because of the additional impacts of such schemes on the adjacent Brecon Beacons National Park and any successful proposal would need to take this into account.

The development of successful renewable energy projects requires sensitivity to the public's concern that while large scale schemes may be meeting the demands of the renewable energy industry they do so at the expense of other environmental and social concerns.

These fears will only be allayed by more transparent consultations and the encouragement of a range of alternative approaches.

The wind turbine industry has had too narrow a focus on the extreme ends of micro-generation (with output up to 15 kW) or major schemes (with outputs of 850 kW upwards) and needs to be encouraged to develop a range of intermediate technologies to fit different needs.

The distinction we would want to make is that there are alternatives to the mega schemes proposed by national energy companies to meeting sustainable energy needs.

The Golden Valley Environment Group would support in principle appropriate solutions for the development of smaller scale wind energy schemes in the county which respect environmental and landscape concerns and minimise their impact on local communities.

Wind energy schemes are an essential component of the diverse renewable energy mix needed to develop sustainable forms of electricity generation in order to meet the Government's carbon reduction targets for 2020.

In our view, the county should support the principle of renewable energy schemes which encourage proposals for medium and relatively small groupings of,possibly, community owned wind turbines in rural, urban and industrial areas.

The potential for smaller scale schemes and their distribution would also need to be evaluated against environmental and landscape impacts and the degree to which local communities would be involved in designing, financing and managing such schemes.

Peter Gunn-Wilkinson
Secretary, Golden Valley Environment Group.

APPENDIX 2
Field trial of survey materials

Opinion Poll

First field trial 10th December 2009

General remarks

The first trial was conducted on Thursday 10th December in the South Herefordshire market town of Ross on Wye. Despite this being market day there was noticeably thin pedestrian traffic around the town centre, yet the roads were constantly clogged with vehicles. In particular, younger people were under represented. Rather than selecting every fifth passer by it was reasonable to approach the first person in range after each interview ended. The surveying was conducted in three sessions of one and half hours, one hour and three quarters of an hour from late morning to early evening.

Demographic.
The dearth of younger people meant that a random selection of pedestrians, the initial strategy, resulted in a preponderance of retired respondents. Consequently for the later sessions a deliberate attempt was made to select the younger people from passers by; a kind of informal targeted stratification. It was notable that in the morning and at lunch time most young people approached cried off (no time!!). The most common reasons given were car park time limits and limited lunch breaks. The issue of residence also arose as many people approached were not resident in the county (Ross being a border town with Gloucestershire and Gwent). On the whole the S-E strata surveyed were above average, to be expected during working hours. Like younger people, those approached that were obviously “at work” were unable to give their time. Only approachees who declined to answer the opening question (are you on the electoral roll in Herefordshire?) were recorded on the sheet as refusals.

Practicalities
To begin with the photographic images of turbines were used as the cue cards, starting with the smallest and moving up. Most respondents appeared able to grasp the increase in scale from small to medium, but there were some anomalous responses suggesting that the images could be greatly improved. Use of the line drawing cue cards caused difficulties for the first few respondents, people failing to grasp the differences, especially between medium and large scale. Consequently use of these was dropped. The better solution to this would seem to be use of an appropriate photo image with a drawn on scaling feature; such as a house outline, to emphasise the variation. There is a risk of assuming that everyone understands dimensioned line drawings which are in fact a cultural construct.

There are evident issues with the wording of the opinion statements, especially the negative statement 3. This clearly caused problems for some respondents deciding whether they agreed or disagreed. In the later sessions this statement was addressed first, making it appear clearer to the respondents. However, by placing the negative at the front of the interview an agreement logically negated the point of the other statements, yet when pressed people seemed to reconsider their position on the ownership issue. It was sometimes difficult to restrain respondents to focus on the one type of turbine in the picture; many showed awareness of commonly raised issues (noise, visual impact) and tried to draw these issues into their consideration, one even refusing to continue because she said there was not enough information to give proper answers. Many respondents were able to correctly guess the order of magnitude of the energy output, which suggests that they may have been subliminally cued, or that the format of the question leads to this result.

After each interview the record sheet was replaced with a fresh one and refusals recorded by count until a respondent was found. No attempt was made to record any demographic data on the refusals.

Gross demographic data
N = 33 Tallied refusers = 58 (64%)
Q1 nTown = 19; nCountryside = 14

Males 14
Females 19

AGES
18 -30 =   3
31 – 40 = 6
41 – 50 = 7
51 – 65 = 8
65 + =   9

Socio – economic strata

D/E = 2
C2   = 10
C1   = 5
A /B = 16

Initial impressions

Many respondents indicated prior knowledge, they had seen windfarm sites in Wales or elsewhere in Europe so had a good sense of what the images represented. It may be worth re -instating the question *have you seen any wind turbines in Herefordshire* to see if this prior experience has any impact on attitude, but this issue has been well studied already. At least two had previously considered having their own micro turbine and one had installed one. One respondent turned out to be a wind farm installation engineer on leave from Germany. In addition it was clear that many had followed the “ debate” to some degree, as shown by comments on noise, “too big” “don't work” etc. A number showed a clear distinction in responses between the different sizes of turbines. For many, the matter of ownership was a non issue, with no clear idea of how a project could be locally owned “we cant find that sort of money here”.

APPENDIX 3
Frequency tables of survey results.

Each demographic block shows unweighted frequency and *percentages* of summed scores ; (left hand edge), for each turbine size, S, M and L.

The first block is for the entire sample N = 500; with weighted scores alongside.

Frequency of Bias Scores

	S	%	M	%	L	%
-4	9	*1.8*	30	*6.0*	68	*13.6*
-3	4	*0.8*	12	*2.4*	33	*6.6*
-2	26	*5.2*	59	*11.8*	80	*16.0*
-1	8	*1.6*	29	*5.8*	33	*6.6*
0	188	*37.6*	213	*42.6*	167	*33.4*
1	25	*5*	21	*4.2*	10	*2.0*
2	158	*31.6*	97	*19.4*	77	*15.4*
3	18	*3.6*	10	*2.0*	7	*1.4*
4	64	*12.8*	29	*5.8*	25	*5.0*
	500	***100***	**500**	***100.0***	**500**	***100.0***

Weighted Frequency of bias scores

	S	%	M	%	L	%
-4	9	*1.8*	31	*6.2*	69	*13.8*
-3	4	*0.8*	12	*2.4*	33	*6.6*
-2	27	*5.4*	60	*12.0*	82	*16.4*
-1	8	*1.6*	29	*5.8*	32	*6.4*
0	187	*37.4*	212	*42.4*	165	*33.0*
1	25	*5.0*	21	*4.2*	10	*2.0*
2	158	*31.6*	97	*19.4*	78	*15.6*
3	18	*3.6*	10	*2.0*	7	*1.4*
4	64	*12.8*	28	*5.6*	24	*4.8*
	500	***100.0***	**500**	***100.0***	**500**	***100.0***

Domicile

Rural

	S	%	M	%	L	%
-4	5	*2.6*	10	*5.2*	27	*13.9*
-3	1	*0.5*	6	*3.1*	16	*8.2*
-2	10	*5.2*	24	*12.4*	29	*14.9*
-1	3	*1.5*	14	*7.2*	16	*8.2*
0	81	*41.8*	88	*45.4*	66	*34.0*
1	12	*6.2*	10	*5.2*	5	*2.6*
2	50	*25.8*	26	*13.4*	24	*12.4*
3	8	*4.1*	4	*2.1*	4	*2.1*
4	24	*12.4*	12	*6.2*	7	*3.6*
	194	***100.0***	**194**	***100.0***	**194**	***100.0***

Town

	S	%	M	%	L	%
-4	4	*1.3*	20	*6.5*	41	*13.4*
-3	3	*1.0*	6	*2.0*	17	*5.6*
-2	16	*5.2*	35	*11.4*	51	*16.7*
-1	5	*1.6*	15	*4.9*	17	*5.6*
0	107	*35.0*	125	*40.8*	101	*33.0*
1	13	*4.2*	11	*3.6*	5	*1.6*
2	108	*35.3*	71	*23.2*	53	*17.3*
3	10	*3.3*	6	*2.0*	3	*1.0*
4	40	*13.1*	17	*5.6*	18	*5.9*
	306	***100.0***	**306**	***100.0***	**306**	***100.0***

SEX

Men

	S	%	M	%	L	%
-4	4	*1.62*	17	*6.88*	27	*10.93*
-3	3	*1.21*	6	*2.43*	14	*5.67*
-2	15	*6.07*	24	*9.72*	37	*14.98*
-1	4	*1.62*	17	*6.88*	15	*6.07*
0	90	*36.44*	99	*40.08*	90	*36.44*
1	11	*4.45*	8	*3.24*	4	*1.62*
2	76	*30.77*	56	*22.67*	45	*18.22*
3	7	*2.83*	5	*2.02*	3	*1.21*
4	37	*14.98*	15	*6.07*	12	*4.86*
	247.0	***100.0***	**247.0**	***100.0***	**247.0**	***100.0***

Women

	S	%	M	%	L	%
-4	5	*1.98*	13	*5.2*	41	*16.3*
-3	1	*0.4*	6	*2.4*	19	*7.5*
-2	11	*4.37*	35	*13.9*	43	*17.1*
-1	4	*1.59*	12	*4.8*	18	*7.1*
0	98	*38.89*	113	*44.8*	76	*30.2*
1	14	*5.56*	13	*5.2*	6	*2.4*
2	81	*32.14*	41	*16.3*	32	*12.7*
3	11	*4.37*	5	*2.0*	4	*1.6*
4	27	*10.71*	14	*5.6*	13	*5.2*
	252.0	***100.0***	**252.0**	***100.0***	**252.0**	***100.0***

Frequency tables for Age groups

Group 1, 18 - 29; Group2, 30 - 39; Group 3, 40 - 49; Group 4, 50 -65, Group 5, 65+

AGE

Group1	s	%	m	%	l	%
-4	1	*1.19*	3	*3.6*	4	*4.8*
-3	0	*0*	1	*1.2*	2	*2.4*
-2	3	*3.57*	8	*9.5*	12	*14.3*
-1	0	*0*	3	*3.6*	3	*3.6*
0	23	*27.38*	33	*39.3*	38	*45.2*
1	2	*2.38*	2	*2.4*	3	*3.6*
2	37	*44.05*	27	*32.1*	14	*16.7*
3	0	*0*	0	*0.0*	1	*1.2*
4	18	*21.43*	7	*8.3*	7	*8.3*
	84.0	***100.0***	**84.0**	***100.0***	**84.0**	***100.0***

Group2	s	%	m	%	l	%
-4	0	*0*	3	*4.5*	5	*7.6*
-3	0	*0*	1	*1.5*	3	*4.5*
-2	3	*4.55*	4	*6.1*	9	*13.6*
-1	1	*1.52*	4	*6.1*	4	*6.1*
0	22	*33.33*	28	*42.4*	25	*37.9*
1	4	*6.06*	4	*6.1*	3	*4.5*
2	22	*33.33*	12	*18.2*	8	*12.1*
3	5	*7.58*	4	*6.1*	2	*3.0*
4	9	*13.64*	6	*9.1*	7	*10.6*
	66.0	***100.0***	**66.0**	***100.0***	**66.0**	***100.0***

Group3	s		m		l	
-4	1	*0.98*	2	*1.9*	10	*9.6*
-3	1	*0.98*	2	*1.9*	9	*8.7*
-2	4	*3.92*	6	*5.8*	12	*11.5*
-1	2	*1.96*	10	*9.6*	9	*8.7*
0	41	*40.2*	50	*48.1*	40	*38.5*
1	4	*3.92*	8	*7.7*	3	*2.9*
2	30	*29.41*	15	*14.4*	13	*12.5*
3	8	*7.84*	4	*3.8*	3	*2.9*
4	11	*10.78*	7	*6.7*	5	*4.8*
	102	***100***	**104**	***100***	**104**	***100***

Group4	s		m		l	
-4	4	*2.88*	9	*6.5*	27	*19.4*
-3	0	*0*	5	*3.6*	10	*7.2*
-2	6	*4.32*	21	*15.1*	25	*18.0*
-1	4	*2.88*	8	*5.8*	12	*8.6*
0	61	*43.88*	62	*44.6*	39	*28.1*
1	9	*6.47*	4	*2.9*	1	*0.7*
2	36	*25.9*	22	*15.8*	19	*13.7*
3	4	*2.88*	2	*1.4*	1	*0.7*
4	15	*10.79*	6	*4.3*	5	*3.6*
	139.0	***100.0***	**139.0**	***100.0***	**139.0**	***100.0***

Group 5	s		m		l	
-4	3	*2.8*	13	*12.1*	22	*20.6*
-3	3	*2.8*	3	*2.8*	9	*8.4*
-2	10	*9.35*	20	*18.7*	22	*20.6*
-1	1	*0.93*	4	*3.7*	5	*4.7*
0	39	*36.45*	40	*37.4*	25	*23.4*
1	6	*5.61*	3	*2.8*	0	*0.0*
2	33	*30.84*	21	*19.6*	23	*21.5*
3	1	*0.93*	0	*0.0*	0	*0.0*
4	11	*10.28*	3	*2.8*	1	*0.9*
	107	***100***	**107**	***100***	**107**	***100***

To convert these unweighted values to representative cell frequencies they were multiplied by a weighting factor of ;

(proportional census cell frequency/ survey sample cell frequency).

example;
Group 5 has a sample count of 107 compared to census 132. The sample frequency for score -2 is 10. So weighted frequency of score -2 for age group 5 is;

10 x 132/107 = 12.3

Frequency tables for Socio Economic groups.

A+B	s	%	m	%	l	%
-4	4	*3.1*	7	*5.4*	20	*15.5*
-3	0	*0*	4	*3.1*	11	*8.5*
-2	8	*6.2*	16	*12.4*	21	*16.3*
-1	3	*2.33*	11	*8.5*	17	*13.2*
0	55	*42.64*	62	*48.1*	35	*27.1*
1	14	*10.85*	7	*5.4*	3	*2.3*
2	24	*18.6*	11	*8.5*	13	*10.1*
3	3	*2.33*	1	*0.8*	0	*0.0*
4	18	*13.95*	10	*7.8*	9	*7.0*
0.0	**129.0**	***100.0***	**129.0**	***100.0***	**129.0**	***100.0***

C1	s	%	m	%	l	%
-4	3	*2.54*	7	*5.9*	18	*15.3*
-3	2	*1.69*	5	*4.2*	10	*8.5*
-2	3	*2.54*	14	*11.9*	11	*9.3*
-1	3	*2.54*	6	*5.1*	12	*10.2*
0	41	*34.75*	50	*42.4*	39	*33.1*
1	6	*5.08*	6	*5.1*	3	*2.5*
2	41	*34.75*	20	*16.9*	16	*13.6*
3	10	*8.47*	5	*4.2*	4	*3.4*
4	9	*7.63*	5	*4.2*	5	*4.2*
	118.0	***100.0***	**118.0**	***100.0***	**118.0**	***100.0***

C2	s	%	m	%	l	%
-4	1	*0.81*	9	*7.3*	15	*12.1*
-3	1	*0.81*	3	*2.4*	10	*8.1*
-2	7	*5.65*	17	*13.7*	21	*16.9*
-1	1	*0.81*	5	*4.0*	1	*0.8*
0	49	*39.52*	44	*35.5*	44	*35.5*
1	2	*1.61*	4	*3.2*	1	*0.8*
2	43	*34.68*	31	*25.0*	24	*19.4*
3	2	*1.61*	3	*2.4*	3	*2.4*
4	18	*14.52*	8	*6.5*	5	*4.0*
	124.0	***100.0***	**124.0**	***100.0***	**124.0**	***100.0***

D+E	s	%	m	%	l	%
-4	1	*0.78*	7	*5.4*	15	*11.6*
-3	1	*0.78*	0	*0.0*	2	*1.6*
-2	8	*6.2*	12	*9.3*	27	*20.9*
-1	1	*0.78*	7	*5.4*	3	*2.3*
0	43	*33.33*	57	*44.2*	49	*38.0*
1	3	*2.33*	4	*3.1*	3	*2.3*
2	50	*38.76*	35	*27.1*	24	*18.6*
3	3	*2.33*	1	*0.8*	0	*0.0*
4	19	*14.73*	6	*4.7*	6	*4.7*
	129.0	***100.0***	**129.0**	***100.0***	**129.0**	***100.0***

To convert these unweighted values to representative cell frequencies they were multiplied by a weighting factor of (proportional census cell frequency/ survey sample cell frequency).

To arrive at the overall weighted frequencies;

$$1/2 \left(\Sigma \ p(age).pc/ps + \Sigma \ p(class).\ pc/ps \right)$$

Where p(age) and p(class) are cell frequencies; pc is cell population in census and ps is cell population in sample. As can be seen by comparing the two overall frequency tables the differences are very small. On this basis, and as they were not found significant, no further work was done to incorporate the weighting of cells by sex or domicile.

APPENDIX 4

Treatment of Likert - type data.

The practice of adding scores from Likert - type survey questions remains controversial, as does calculation of "normal" measures of central tendency and spread; (ie mean and standard deviation) and the use of parametric correlation and significance tests. The practice of adding scores is challenged on the basis of equivalence of values between two or more response ranges; in other words do the scores from one question have the same absolute magnitude as the scores from another.?In this study the questions on attitude were designed to be logically opposite tests of the same underlying construct, bias for or against wind turbines in the area. In addition, as the positions proposed in the questions were extreme; 'allow everywhere vs. allow nowhere'; it is argued that results can be treated as common in magnitude and suitable for giving the kind of *indicative* results required for a preliminary study of this kind.

Whilst it is considered mathematically not correct to calculate means and variances etc. from scores on Likert scales (Moser & Kalton 1971; Oppenheim 1992 Procter 1993), it is commonly done in human behavioural sciences. (Statsoft 2010; Jamieson 2004). The debate around it's validity centres on treatment of Likert-type item scores as interval or continuous variables representing an underlying psychological phenomenon (such as attitude). The case against can be summarised by the question; given a Likert-type scale score of say 3; then three of *what* has been measured.? In contrast, some social scientists and psychological researchers favour the view that the scale is an attempt to measure a hidden or latent underlying construct which *may* be considered a continuous rather than discrete quantity (Clason & Dormody 1994). It is used here on the summed scores from tied pairs in six data points for each respondent (two questions each for three turbine sizes) to derive a numerical quantity to represent *group* bias for or against wind energy projects. Some methodological research comparing true likert-type scales against allowing the subject to place a mark on an undivided continuous line between extremes then measuring it's length has shown that;

> *"the models' response assumptions were reasonably tenable and ... the solutions obtained in all cases were similar. More complex models did not lead to substantial improvement in predictive validity."*

(Ferrando 1999 Article abstract)

It would have been useful to trial different scoring methods along with other matters in the field trial, and this issue should inform any future work in this matter. It is accepted that a formal factor analysis technique would possibly be mathematically more correct (Moser & Kalton op cit) but this would be more time consuming and make the results less accessible to opinion shapers and policy makers to whom the reported results of the survey would be aimed. Another mathematically robust analytical technique, ordinal regression analysis, requires proprietary software beyond the resources of this writer, both in cost and training time. This remains a live issue among workers in Human Behavioural Sciences both pure and applied and a useful example of the arguments is found in sci.stat.edu (Cliff 2010). To quote a contributor to this,

> *1. Likert scales may give erroneous answers BUT;*
> *2. They are widely used.*
> *3. If [researchers] really want to know the answer interval analysis of Likert scales are good for pilot work but cannot give definitive answers.*
> *4. If the interval analyses give very large EFFECT SIZES, as opposed to very low p*

values the effect is certainly there.

5. If the objective is making a decision such as chose 'product 1' rather than 'product 2' then [one] is unlikely to make a mistake based on interval analysis.

6. If interested in the MAGNITUDE of the effect, then interval analyses are flawed.

(sci.stat.edu Bulletin Board post by Prof. D. Kornbrot.)

In terms of this study, item 3 is satisfied by the overall aim of the work, to discover if any relationships even exist; item 4 is satisfied by the consistency in strength of significance tests (**Table 4.8**); item 5 reflects the aim to find an optimum turbine size for the county. Item 6 is noted, but here only one summed Likert-type series is involved, overall bias score, indicative of the extent of bias within that population. In other words, if a high average bias score indicates more supportive responses among that sample than lower scores would, then this can be considered an indicator variable for the relative response of any given group to a local wind energy project. In addition, for the core issue of interest in the study results can be tested for significance using more robust tools, such as Chi square testing. Finally, some sources suggest that any sufficiently large sample may be analysed by parametric methods, an argument based on the central limit theorem; with samples exceeding one hundred items suggested as a threshold (Statsoft 2010). This study uses five hundred data sets of six items each, three thousand items, for the analysis. For the parametric type testing of the bias scores, the full range of this data is used. The pragmatic balance required is between sufficient rigour to make analysis meaningful; resources available and clarity of the outputs to permit wide understanding.

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