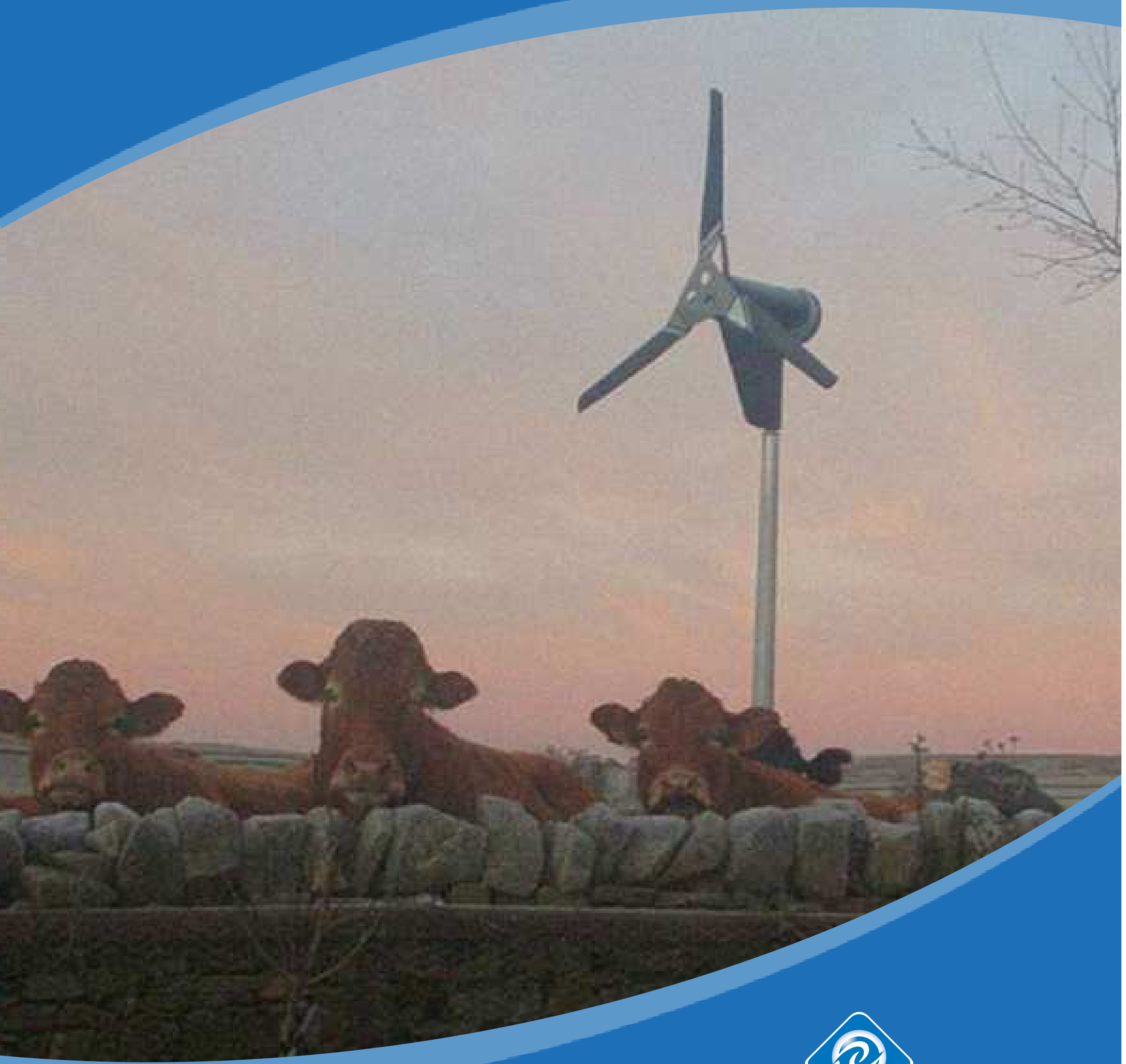
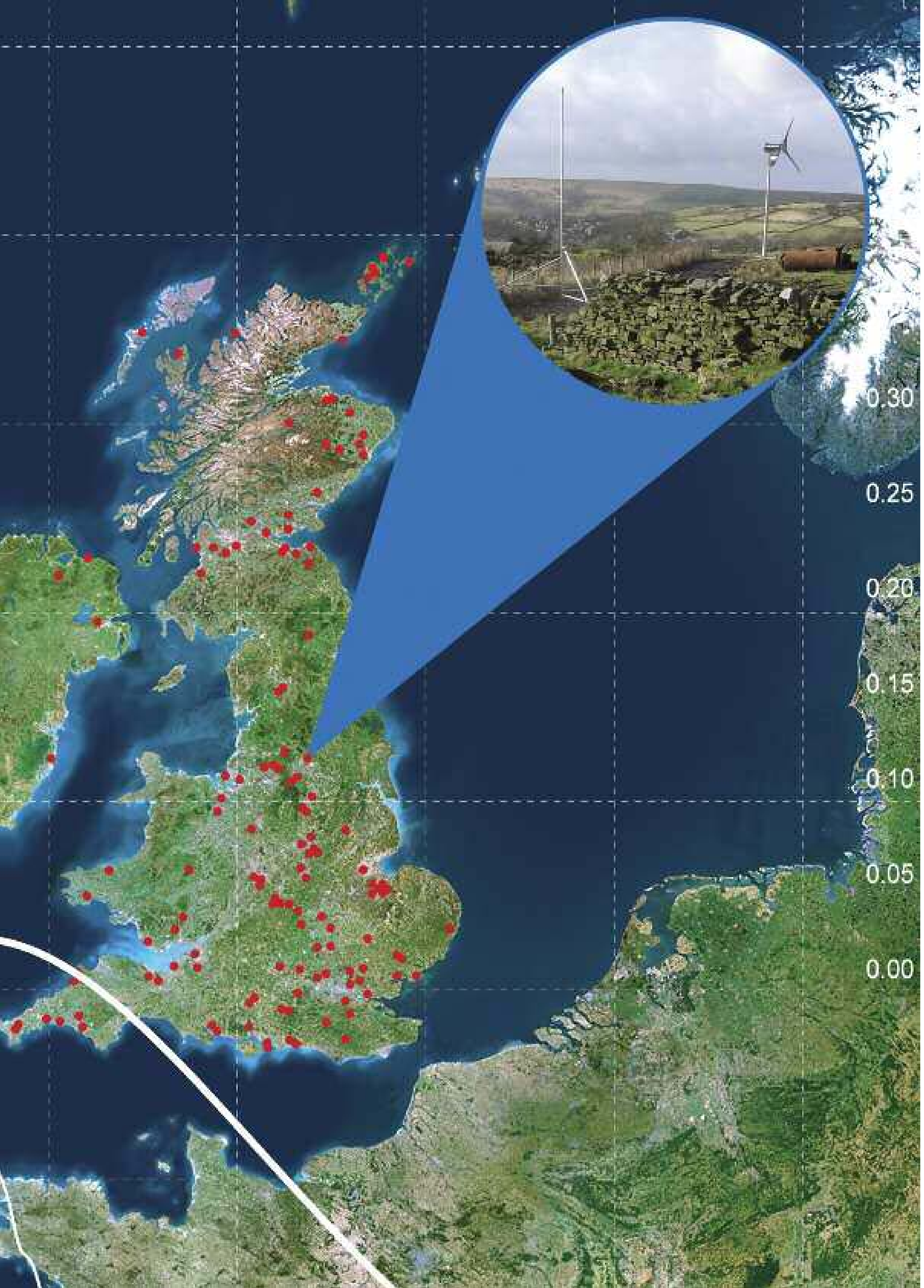
Location, location, location

Domestic small-scale wind field trial report

July 2009



energy saving trust®



Foreword

The Energy Saving Trust's work in small-scale domestic wind dates back to 2005. A report compiled for the DTI[1] concluded that 'with the appropriate support, small wind could supply four per cent of the UK electricity requirement and reduce domestic CO_2 emissions by six per cent'. Subsequently, our reports 'Microwind Electricity Generation in the UK Residential Sector' and 'Generating the Future', both completed in 2007, provided further predictions of the potential market for small wind turbines in the UK by 2050. These projections were based on modelled data and were produced before actual performance data from small-scale wind turbines was widely available. As such, it was difficult at the time to determine the accuracy of such future projections. Since these reports were published, the UK market for domestic small-scale wind has developed rapidly.

In 2007, the Energy Saving Trust launched the first-ever comprehensive monitoring programme of domestic small scale wind turbines in the UK. The main aim was to determine how the technology performs when installed in ordinary people's homes. As a result of this field trial, we can now provide a better indication of the realistic opportunities for installing domestic small-scale wind turbines in the UK.

The Energy Saving Trust has also improved the quality of information available to the public about the performance of small wind turbines, and our network of 21 UK advice centres are now trained to provide individual consumers with advice on whether small wind is likely to be a suitable technology for them. Additionally we are working further with policymakers and industry to improve product and installation standards so future customers will be able to purchase products that are developed and installed to consistent guidelines.

This project forms part of the Energy Saving Trust's extensive market transformation activities in the household-scale low-carbon technology sector, which stem from policy research, through technical testing, to consumer advice. We intend to release results from similar field trials of domestic heat pump and solar water heating installations in the forthcoming 18 months.

The Energy Saving Trust would like to thank our partners who have made this work possible:

EDF Energy

RWE npower

NIE Energy

Centrica plc

ScottishPower Ltd

Scottish and Southern Energy plc

E.ON Engineering Ltd

The Scottish Government

The Department of Energy and Climate Change

B&Q plc

The University of Southampton

Energy Saving Trust Project Team:

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1.The Department for Trade and Industry, http://www.dti.gov.uk/files/file27558.pdf

Executive summary

The Energy Saving Trust's field trial of domestic wind turbines is the most comprehensive technical monitoring exercise of this technology undertaken to date in the UK. The field trial was developed and launched in January 2007 to monitor the actual in-situ performance of a statistically robust sample of turbines installed at real peoples' homes. The results of the trial will enable the Energy Saving Trust to provide detailed advice to policymakers, the industry, and customers about the actual performance of the technology.

The Energy Saving Trust identified a representative sample of participants and products to participate in the field trial. Sites were identified from a selection of grant recipients who had installed either building mounted or free standing (pole mounted) domestic small scale wind turbines as well as further sites put forward by wind turbine manufacturers. The Energy Saving Trust has maintained a close relationship with householders participating in the trial throughout the duration of the project.

This report illustrates the technical factors that impact on the performance of domestic small-scale wind turbines, including installation and proper siting. Turbine performance is also highly dependent upon the local wind speed, and, as such, the research undertook an assessment of the accuracy of wind speed prediction models and recommends the most suitable option for customers. It is essential to accurately predict the wind speed before installing a domestic small-scale turbine because the performance is shown to be directly dependent upon the locally available wind speeds.

The report also discusses the different methods that manufacturers use to provide information about their turbines to potential consumers. To date, there have been minimal standards in place to regulate the information available to customers. As such, it has been difficult to determine which model of turbine might be appropriate for a particular customer, or whether a turbine is indeed the most appropriate technology. The report recommends that industry standards need to be agreed and implemented to ensure consumers receive adequate information regarding the potential energy generation from a domestic-scale wind turbine.

The Energy Saving Trust previously undertook policy research to model the potential size of the UK market for small-scale wind. The results from the current field trial provide a much clearer view of the potential for domestic small-scale wind in the UK, and also facilitate improved advice and guidance for consumers. Rural, exposed areas are particularly well suited and Scotland is seen to have the greatest potential for successful installations in the UK.

The report also discusses the results of the UK's first domestic small-scale wind customer feedback exercise. This exercise illustrates customers' motivations for purchasing the technology and recommends ways that advice from both the Energy Saving Trust and installers/manufacturers can be improved to potential customers.

As a result of this comprehensive study, potential customers should be aware of the key points before choosing to install a domestic wind turbine:

- Wind turbines do work but only when installed properly in an appropriate location.
- There is a potential for delivering carbon savings and energy generation from domestic small-scale wind turbines in the UK.
- The highest potential for successful household small-scale wind installations is in Scotland.
- Wind speeds are difficult to predict and highly variable. The Energy Saving Trust recommends that potential customers first utilise the best available wind speed estimation tools and then, where appropriate, install anemometry to determine the wind speed distribution.
- The introduction of product and installation standards will require that information from specific products is easily comparable.
- Customers are advised to only consider domestic small-scale wind products and installers that are certified under the Microgeneration Certification Scheme.
- The Energy Saving Trust advice network is able to provide advice to customers to help determine if a wind turbine may be the right choice for their homes.
- Domestic consumers should consider energy produced from small-scale wind as one option from a potential suite of microgeneration technologies.

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Introduction

The Energy Saving Trust is an independent, UK-based organisation focused on promoting action that leads to the reduction of carbon dioxide emissions - the main greenhouse gas causing climate change – by promoting the sustainable and efficient use of energy.

The Energy Saving Trust is a non-profit making organisation that acts as a bridge from Government to consumers, trade, businesses, local authorities and the energy market. We provide impartial information and advice and have a UK-wide network of advice centres specifically designed to help domestic consumers take action to save energy.

The Energy Saving Trust has a well established reputation of developing and delivering a portfolio of projects to monitor the in-situ performance of energy efficiency and low carbon technologies. The objective of each project is to determine the actual performance and carbon savings when used by domestic customers. Monitoring projects allows the Energy Saving Trust to understand how customers use new, innovative technologies and enables us to identify the potential uptake of the technology in future.

Background

There has been very little independently assessed performance data available from domestic small-scale wind turbine installations in the UK[2]. Although incentive programmes such as the Low Carbon Buildings Programme[3] (LCBP) and the Energy Saving Scotland Home Renewables Grant Scheme[4] (previously known as SCHRI) have awarded grants to householders to promote the uptake of small-scale wind turbines and other microgeneration technologies, there is no provision to monitor and collect performance data from installations. Customers have instead relied upon manufacturers' performance claims and the recommendations of installers when making a decision to install a domestic-scale wind turbine.

The Energy Saving Trust identified that the lack of independently assessed performance data poses a barrier for potential domestic consumers. Additionally, accurate wind speed data is not readily available for many potential customers of domestic small-scale wind turbines, especially those in urban locations. Early in 2007 the Energy Saving Trust therefore developed a methodology to monitor the actual performance of domestic small-scale turbines – installed in real homes – as part of a national field trial.

The objectives of the field trial were to collect actual performance and wind speed data from a sample of domestic sites across the UK, report on key findings, and make recommendations based upon the results. The Energy Saving Trust's field trial is the most comprehensive monitoring exercise of domestic small-scale wind turbines undertaken to date in the UK. The field trial monitored the actual in-situ performance of a statistically robust sample of 57 domestic installations for one year ending in March 2009. Because little was known about the actual performance of domestic small-scale turbines, the field trial provides the first detailed analysis of the actual energy generation from domestic installations. The research also provides insight into key areas that can affect domestic wind turbine performance such as the wind speed, turbulence, installation, and siting. As a result of this field trial, the Energy Saving Trust can provide specific advice to consumers, installers, manufacturers, certification bodies, and the Government regarding best practice in these key areas.

The methodology and scope of the field trial was developed through extensive consultation with relevant UK stakeholders including the Government, industry, the energy suppliers, the British Wind Energy Association (BWEA), and various research institutes. Thus, the data has been collected in accordance with robust agreed protocols and the results provide an accurate representation of the actual performance of the monitored wind turbines during the period.

The field trial has been delivered with funding from a wide variety of partners including the Energy Saving Trust, the UK's main energy suppliers (EDF Energy, RWE npower, NIE Energy, Centrica plc, ScottishPower Ltd, Scottish and Southern Energy plc, and E.ON Engineering Ltd), the Scottish Government, Defra and B&Q plc. All funders were represented on the project's advisory group and have been influential in the trial's site selection and results dissemination strategy.

The work undertaken for this project has enabled the Energy Saving Trust to gather the first independent performance data from specific models of wind turbines in the UK. The work provides a detailed analysis and comparison of actual versus predicted turbine performance; makes recommendations for the improvement of industry standards; and identifies key areas where information to the consumer should be improved.

This report presents a discussion of the industry standards for domestic small-scale wind turbines; an analysis of wind speed prediction models and discussion of the implications for future siting of turbines; and undertakes a comprehensive analysis of wind turbine performance. The report also assesses the potential size of the market for domestic-scale wind in the UK, discusses the implications for consumers, and makes recommendations for the future.

Site selection

In early 2007 the Energy Saving Trust engaged with Low Carbon Buildings Programme (LCBP) grant recipients who had installed a building mounted 'micro' wind turbine. These grant recipients were invited to join the trial as fully monitored sites or to provide monthly meter readings. In total 38 building mounted turbines were chosen to be fully monitored for one full year. The first data collected from these sites was available from November 2007. Additional sites – predominantly free standing pole mounted turbines – were added to the field trial in early 2008. These sites were identified from LCBP grant recipients and the manufacturers. In total 19 free standing turbines were chosen to be fully monitored for one full year. Field trial sites included urban, suburban and residential areas; agricultural farms; and remote community schemes such as those in the Orkneys.

In addition to the 57 Energy Saving Trust funded technically monitored sites, householders at 68 additional sites agreed to provide monthly energy generation data, and a further 29 Warwick Wind Trial[5] sites contributed data. The analysis presented in this report focuses predominantly on the technical performance of the 57 Energy Saving Trust monitored sites.

Monitored turbines

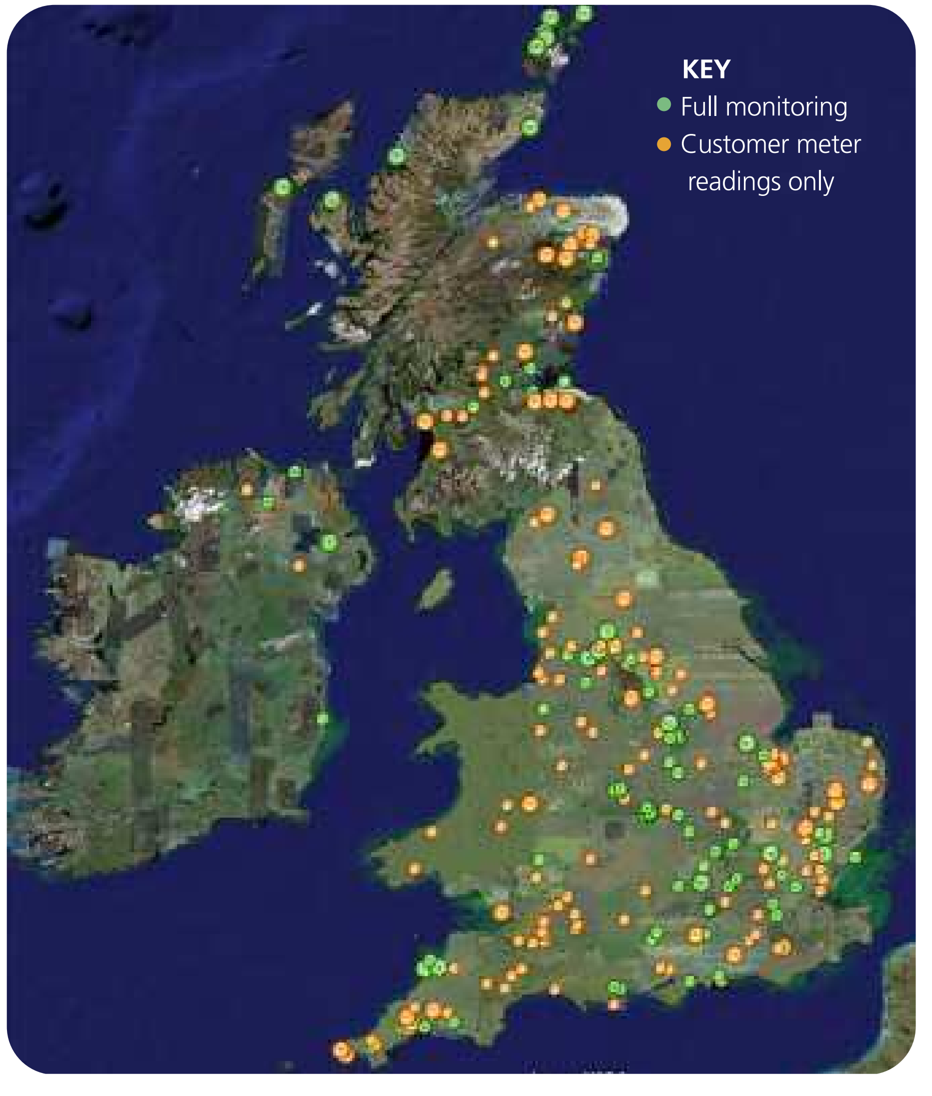
The turbines monitored in the field trial were domestic small-scale building mounted and free standing turbines ranging in rated power output from 400W to 6000W. A turbine's rated power indicates its output (in Watts) at a specified wind speed. Most manufacturers have, to date, chosen to rate their turbines at wind speeds ranging from 11-12.5 m/s. Customers should be aware that manufacturers are not yet required by an industry standard to rate their product at an agreed wind speed, and that turbines begin to produce energy at different wind speeds (known as the 'cut-in' speed). In this report, wind speed is expressed in metres per second (m/s).

2. The field trial monitored domestic wind turbines rated in output from 400W to 6kW
3. Low Carbon Buildings Programme, http://www.lowcarbonbuildings.org.uk/
4. Energy Saving Scotland Home Renewables Grant Scheme, http://www.energysavingtrust.org.uk/scotland/Scotland/Energy-Saving-Scotland-home-renewables-grant-scheme-previously-known-as-SCHRI
5. Warwick Wind Trials, http://www.warwickwindtrials.org.uk/

Table 1 provides a breakdown of turbines monitored within the trial, classified as building mounted or free standing turbines, and lists the rated power, rated wind speed, and cut-in wind speed for each turbine.

	Blade Diameter (m)	Rated Power (W))	Rated wind speed (m/s)	Cut-in wind speed (m/s)
Building mounted turbines:				
Air Dolphin	1.8	1000	12	2.5
Ampair 600	1.7	600	12.5	3.5
Eclectic, D400	1.1	400	15.5	2.5
Swift 1.5kW	2.1	1500	12.5	2.3
Windsave, WS1000	1.75	1000	12.5	4.5
Free standing, pole mounted turbines				
Ampair 600	5.6	600	11.5	2.7
Eoltec	5.6	6000	11.5	2.7
Iskra AT5-1	5.4	5000	11	3
Proven 2.5	3.5	2500	12	2.5
Proven 6	5.5	6000	12	2.5

Figure 1 shows a distribution of field trial sites in the UK.



Domestic wind standards

The domestic small-scale wind turbines monitored in the field trial were installed in 2006-2007. All of the monitored turbines were installed by an installer accredited through the Government's Clear Skies programme (the accreditation programme for domestic-scale microgeneration technologies at the time). Customers now interested in purchasing a domestic small-scale wind turbine should be aware that a number of standards have been introduced since 2007 to improve the installation, design, durability, and rating of domestic small-scale wind turbines sold in the UK. As a result of this field trial, the Energy Saving Trust has actively influenced Government and industry to design and implement the most relevant standards and provide consumers with the most accurate information regarding products, installers, and wind speed prediction.

Turbine performance calculation methods

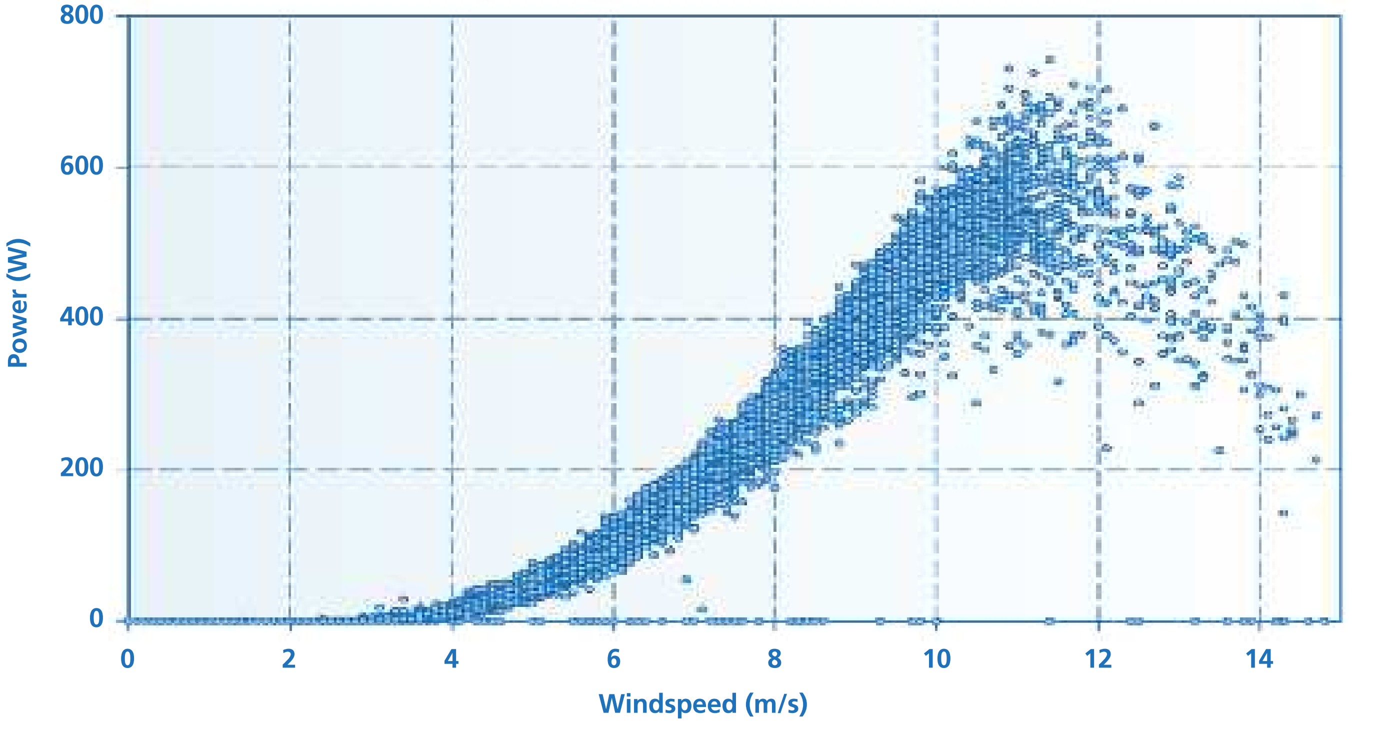
Three methods are commonly used to calculate the predicted performance of small-scale wind turbines and provide information to consumers.

One method is the calculation of a load factor. This calculation is expressed as a percentage of the actual output of a turbine at a specific site compared with its maximum rated output. To date, commonly quoted data has suggested that average expected load factor figures for domestic small-scale wind turbines would be 10 per cent for building mounted turbines and 17 per cent for free standing turbines[6]. Data collected from field trial sites were analysed to determine if these are realistic assumptions. To put these figures in perspective, large, Megawatt-scale commercial on- and off-shore wind turbines in the UK have annual capacity factors of around 30-40 per cent.

The Annual Energy Production (AEP) yield is another method used to calculate the performance of a turbine. This method is part of the British Wind Energy Association (BWEA) standard to determine the 'reference annual energy' generation of small-scale wind turbines and provide an indication of a turbine's annual yield at an average wind speed of 5m/s. Data collected from the field trial was analysed to determine if the manufacturers' claims of annual energy production at average wind speeds of 5m/s were accurate and if this is a suitable wind speed at which to rate turbines for sale in the UK market. Data illustrated that this benchmark wind speed was too high to provide a comparison of AEP at the turbines monitored in the field trial as few sites achieved the average wind speed of 5m/s during the period of data collection.

Additionally, manufacturers quote the output and efficiency of their turbine represented by a power curve. A power curve is generated by plotting measured turbine output at a range of wind speeds on a graph. This indicates to consumers the predicted output at a given range of wind speeds, as shown in **Figure 2.**

Figure 2 Example of a wind turbine power curve



6. BWEA Small Wind Systems: UK Market Report 2008; The Energy Saving Trust, http://www.energysavingtrust.org.uk/corporate/Global-ata/Publications/Generating-the-Future-An-analysis-of-policy-interventions-to-achieve-widespread-microgeneration-penetration

The efficiency of a wind turbine at a given wind speed can be calculated using either manufacturers' claims or actual performance data. The peak efficiencies of the turbines in the field trial, as claimed by the manufacturers, range from 30-60 per cent. The measured peak efficiencies of the turbines monitored in the field trial ranged from 30-45 per cent. Large commercial Mega Watt scale turbines, which are highly optimised, have peak efficiencies of approximately 40 per cent. To put these figures in context, the theoretical maximum efficiency of a wind turbine is 59 per cent, which is known as the Betz limit[7].

These differing methods can be confusing to potential customers. As discussed above, different manufacturers choose to 'rate' their turbine, i.e. claim the rated output figure, at different wind speeds. Further, data collected through this field trial suggests that a number of power curves published by manufacturers, and hence the predictions of potential energy generation, are inaccurate. Thus, it is not easy for consumers to compare the outputs or performance of different products at specific wind speeds. The Energy Saving Trust considers it important that appropriate standards are introduced that would require domestic small-scale turbines to be tested and certified at specific parameters and provide information to the consumer at a standardised protocol. Such harmonised standards would help to eliminate potential confusion for the customer.

Wind speed prediction

In order to most accurately determine the potential performance of a wind turbine at a site, it is important to have an accurate estimate of the wind resource. A commonly accessible predictive model, the Government's Numerical Objective Analysis Boundary Layer (NOABL) database, has until recently been the primary tool used by manufacturers, installers, planning authorities and consultants to determine a site's potential wind speed. This model, which provides annual average wind speeds for a 1km UK grid square, has been shown to overestimate the potential wind speed at many sites in this field trial especially those in urban and suburban locations. This is because the database does not consider the impact of local obstructions, including trees and buildings, in its methodology. As such, potential customers in built up areas have not been able to access accurate estimates of the potential wind speed and thus the likely annual yield and potential cost savings from installing a domestic small-scale wind turbine.

The Energy Saving Trust has, to date, recommended that customers require a minimum NOABL average wind speed prediction of 6m/s before considering the installation of a domestic small-scale wind turbine at a site. Most UK installers, in comparison, have recommended that a potential site have a minimum average NOABL wind speed prediction of 5m/s. There are now a number of additional methods to predict the local wind speed, including an adjustment to NOABL, which has been adopted as part of the Microgeneration Certification Scheme (MCS) installer standards, as discussed above. In March 2009 the Carbon Trust launched a Wind Yield Estimation Tool which takes local topography and obstructions into consideration. The field trial has undertaken an assessment of these wind speed prediction models compared with actual on-site measurements from the 57 field trial sites and readings from Metrological Office observation stations (Met Station) to determine the most accurate model to predict wind speed at a potential domestic location.

Data gathered through the field trial indicates that none of the sites with building mounted turbines had average annual recorded wind speeds of 4m/s or greater, and only a third of free standing pole mounted turbines had average annual recorded wind speeds of 5m/s or greater. It is therefore likely that many sites in the UK have less of a wind resource than previously predicted. Wind turbines are designed to generate exponentially higher output at higher wind speeds[8] and, as such, the low recorded wind speeds illustrate that many of the sites in the field trial – and likely in the UK as a whole – are providing less energy generation than predicted.

Further, it was not possible to determine the Annual Energy Production at a wind speed of 5m/s for a large number of sites in the trial that had average wind speeds less than this figure.

An analysis of wind speed prediction models illustrates that both NOABL and the measured Met. Station approaches over-estimated the predicted wind speed at all sites with a building mounted turbine **(Figure 3)**, largely due to the impact of local obstructions on the wind resource. This result would support the finding that the actual wind speeds measured at the urban and suburban field trial sites was less than predicted. This analysis shows that both the MCS adjusted NOABL and the Carbon Trust (CT) tool predict wind speeds at more realistic levels in urban and suburban areas, and thus represent a significant improvement to wind speed prediction. The trend lines in **Figure 3** (below) and **Figure 4** (overleaf) illustrate perfect agreement between measured site wind speed and the prediction tool. Plots above the trend line illustrate an over prediction by each tool; plots below the line illustrate under prediction.

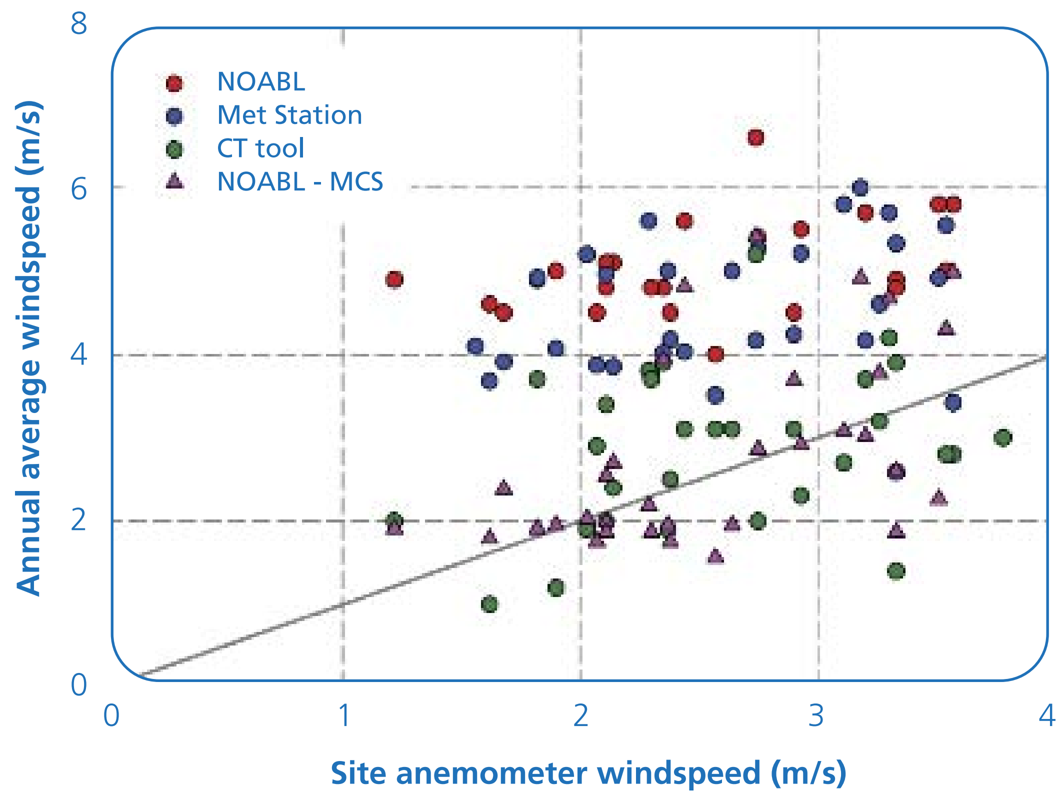


Figure 3
Comparison of wind speed prediction models with anemometer measured wind speed data at fully monitored building mounted turbine sites. Met Station (measured), NOABL (predicted), MCS adjusted NOABL (predicted).

7. http://www.bwea.com/edu/extract.html.

8. The energy available in the wind increases by a power of three as the wind speed increases, meaning that increasing the wind speed by a factor of two would increase the energy available in the wind by a factor of eight.

Most of the monitored free standing turbines **(Figure 4)** were located in remote locations with an undisrupted wind resource. Thus, the NOABL prediction would be expected to provide a better indication of wind speed at these sites compared with building mounted sites. The analysis of site measurements illustrates that NOABL still tends to overestimate the average wind speed at such sites, whereas the MCS adjusted NOABL figure provides an improved prediction. The Met station data and Carbon Trust tool provide the most accurate predictions.

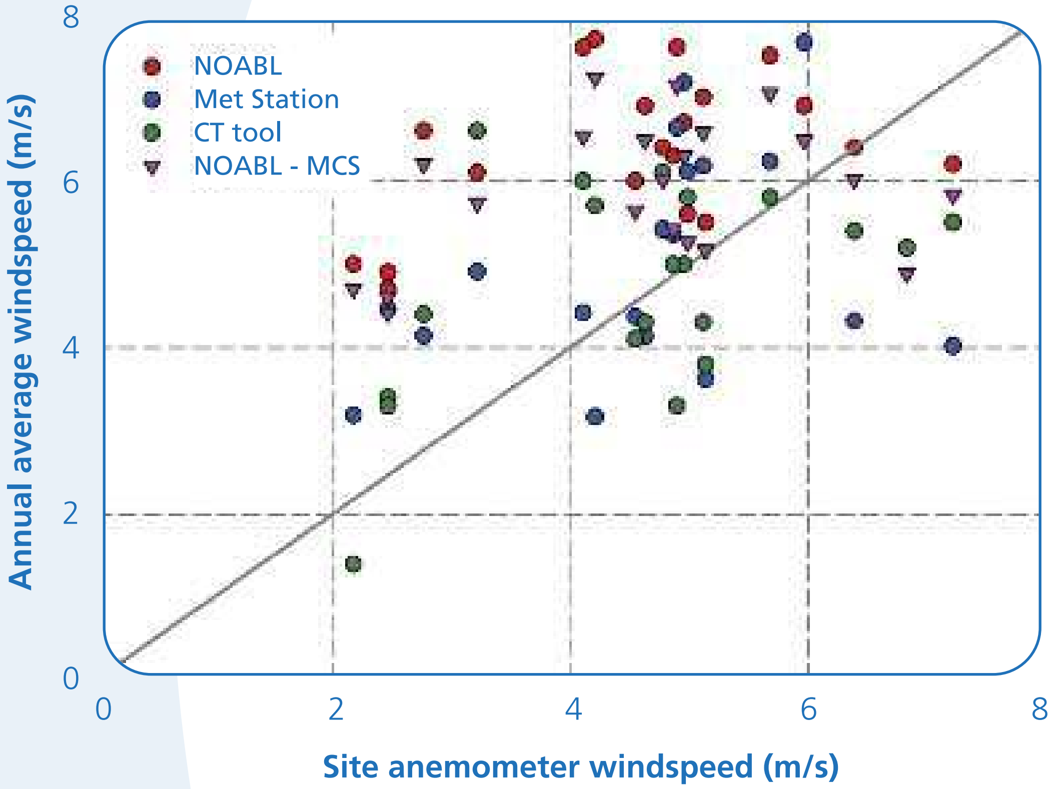


Figure 4
Comparison of wind speed prediction models with anemometer measured wind speed data at fully monitored free standing pole mounted turbine sites. Met Station (measured), NOABL (predicted), MCS adjusted NOABL (predicted),

Anemometry

An anemometer is a piece of equipment that measures the wind speed at a specific site.

Although the field trial illustrates that new wind speed prediction models are more accurate than those previously available, potential customers should realise that there will always be a degree of variability in the actual wind speed at a specific site due to topography and local obstructions. The Energy Saving Trust therefore recommends that a potential customer's site should receive a wind speed prediction of at least 5m/s, when assessed using the MCS adjusted NOABL and/or the Carbon Trust tool, as an accurate starting point to determine whether a domestic small-scale wind turbine may be suitable. The Energy Saving Trust then recommends that, whenever possible, anemometry – which provides measurement of wind speed at a given location – is installed at these sites for a minimum period of three months[9] to measure the actual local wind speed before deciding to install a turbine. Doing so will enable customers to make a purchase decision based upon a more accurate wind speed at their specific site location.

9. The wind speed varies by season. It will be necessary to apply a seasonal adjustment factor to a wind speed measured at a given site if measured for 6 months or less.

Performance results

The field trial has analysed the output and peak efficiencies of domestic-scale turbines to determine their actual in-situ performance when installed in domestic situations.

Building mounted turbines

Results from the field trial illustrate that the building mounted turbines did not approach the commonly quoted load factors of 10 per cent. No urban or suburban building mounted sites generated more than 200kWh or £26 per annum, corresponding to load factors of 3 per cent or less. In some cases, installations were found to be net consumers of electricity due to the inverter taking its power (up to 10W) from the mains supply when a turbine was not generating. The highest load factor from a fully monitored 1.5kW building-mounted turbine located in Scotland was only 7.4 per cent, corresponding to around 975 kWh, or £127[10] of electricity generation per annum. These lower than anticipated performance figures were primarily due to inappropriate installations, both in terms of locations with a poor wind resource and positioning. As mentioned above, all sites with building mounted turbines were found to have an annual measured wind speed of less than 4m/s. Thus, the poor energy performance was a direct result of inadequate wind resource availability. The Energy Saving Trust therefore recommends that sites achieve a minimum average annual wind speed of 5m/s.

Building mounted turbines performed best when mounted on the gable end of a building, positioned above the ridge line and located in remote rural locations, usually individual dwellings near the coast or on exposed land with an undisturbed flow from the direction of the prevailing wind. Turbines were shown to perform broadly in line with manufacturers' power curve prediction at the majority of sites. Whilst building mounted turbines can work, it must be emphasised that their successful performance is highly dependent upon an adequate, unobstructed, wind resource and appropriate siting of the turbine.

Free standing turbines

The best performing free standing sites in the field trial were always remote rural locations, usually individual dwellings near the coast or on exposed land such as moors. The in-situ results from these sites illustrate that the performance of free standing turbines frequently exceeded commonly quoted annual load factors of 17 per cent. In fact, the average monitored load factor was 19 per cent, and the best sites had load factors of 30 per cent or greater. A 6kW turbine with a 30 per cent load factor would be expected to produce approximately 18,000kWh per annum, which equates to £2,340. Additionally, annual generation also agreed closely with the manufacturer's predictions.

Many of the free standing turbine sites had a measured average annual wind speed greater than those sites with a building mounted turbine. In fact seven sites had measured wind speeds greater than 5m/s. Free standing turbines sited in built up areas did not perform as well, again due to the insufficient wind resource.

10. Assuming a cost of 13p per kWh. £127 is the maximum savings if all electricity is consumed on-site.

Potential market for domestic small-scale wind turbines

The Energy Saving Trust completed a report for the DTI[11] in 2005 that concluded ‘with the appropriate support, small wind could supply four per cent of the UK electricity requirement and reduce domestic CO_2 emissions by six per cent’. Subsequent Energy Saving Trust research, ‘Generating the Future ’, completed in 2007[12], predicted that with a range of policy interventions, up to five million small-scale domestic wind turbines could be installed in the UK by 2020 if turbines are installed widely in urban areas. Subsequently, the Carbon Trust released a report[13] in 2008 which predicted that small-scale wind, when installed at 10 per cent of UK sites (both domestic and commercial) with adequate wind speeds, could produce 1500 GWh annually, which equates to 0.36 per cent of the UK electricity supply.

The Energy Saving Trust has followed up the field trial work with an assessment of the potential number of domestic small scale wind turbine (400W to 6kW) installations, similar to those monitored through this project, at domestic sites in the UK with a suitable wind speed of at least 5m/s[14]. The analysis has indicated that, with current economic incentives, there are likely to be at approximately 455,650 domestic properties in the UK that would have a suitable wind resource of at least 5m/s and adequate land area and/or building profiles. The figure of 455,650 potential installations equates to 1.9 per cent of UK households and was based upon an analysis of suitable sites including farms and households in three regions of the UK: England and Wales, Scotland and Northern Ireland. The analysis has assumed that only one turbine will be installed at a potential site.

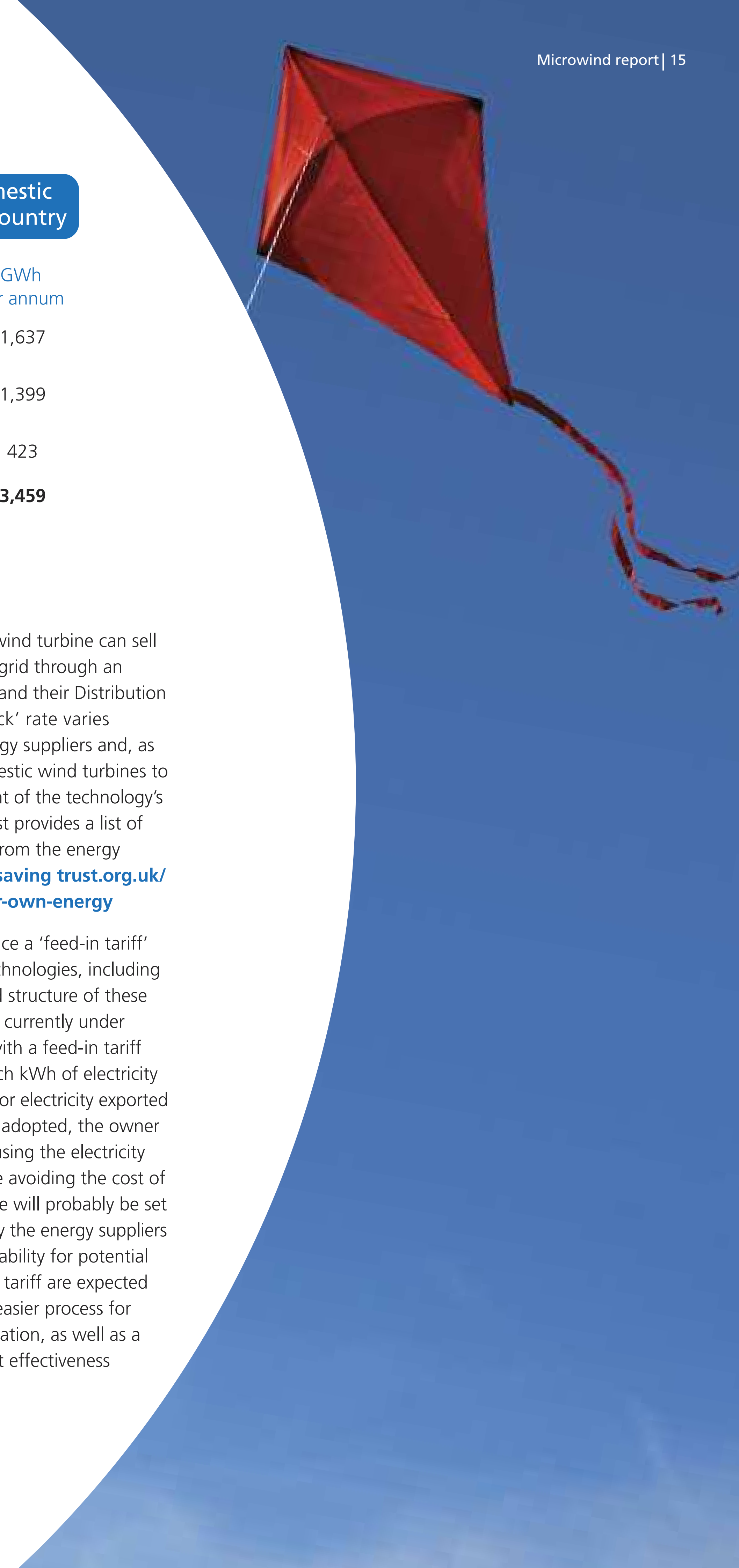
Gross annual generation from these turbines, if installed at 100 per cent of sites meeting the minimum wind speed and siting criteria, would be approximately 3,459GWh per annum, as shown in **Table 2**. 3,459GWh equates to the amount of electricity used by approximately 870,000 households per year which is approximately 0.9 per cent of UK electricity supply and 3.1 per cent of domestic energy demand[15].

The analysis (right) is based upon current economics and state of the technology. Manufacturers are working to improve their products in accordance with the Microgeneration Certification Scheme and, as such, future technology may perform better at lower wind speeds which in turn could increase the size of the potential domestic market in the UK in terms of number of installations and potential energy generation. Until these technologies are proven, the Energy Saving Trust will continue to recommend 5m/s as a minimum wind speed for the installation of a domestic small-scale wind turbine.

Potential number of UK domestic small-scale wind turbines.

Location	Number of turbines	GWh per annum
Pole mounted turbines - farms		
England and Wales	62,250	781
Scotland	36,200	610
Northern Ireland	16,100	249
Pole mounted turbines - buildings with significant land		
England and Wales	68,400	792
Scotland	43,500	732
Northern Ireland	10,400	163
Building mounted turbines		
England and Wales	104,600	64
Scotland	93,000	57
Northern Ireland	21,200	11
Total UK	**455,650**	**3,459**

11. The Department for Trade and Industry, http://www.dti.gov.uk/files/file27558.pdf
12. The Energy Saving Trust, http://www.energysavingtrust.org.uk/corporate/Global-Data/Publications/Generating-the-Future-An-analysis-of-policy-interventions-to-achieve-widespread-microgeneration-penetration
13. Carbon Trust (2008) Small-scale wind energy: Policy insights and practical guidance. London: Carbon Trust, http://www.carbontrust.co.uk/technology/technologyaccelerator/small-wind.htm
14. The Energy Saving Trust recommends using the Microgeneration Certification Scheme adjusted NOABL methodology or the Carbon Trust tool to predict wind speed at a site.
15. Digest of United Kingdom energy statistics 2008, http://stats.berr.gov.uk/energystats/dukes08.pdf.



Potential number of UK domestic small-scale wind turbines by country

Location	Number of turbines	GWh per annum
England and Wales	235,250	1,637
Scotland	172,700	1,399
Northern Ireland	47,700	423
Total UK	**455,650**	**3,459**

Financial incentives for domestic small-scale wind

At present, domestic customers with a wind turbine can sell excess electricity generated back to the grid through an arrangement with their energy supplier and their Distribution Network Operator (DNO). The ‘buy-back’ rate varies considerably amongst the different energy suppliers and, as such, it is difficult for customers of domestic wind turbines to undertake a rigorous financial assessment of the technology’s financial viability. The Energy Saving Trust provides a list of the ‘buy-back’ rates currently available from the energy suppliers on it’s website: **www.energysaving trust.org.uk/Generate-your-own-energy/Sell-your-own-energy**

The Government is proposing to introduce a ‘feed-in tariff’ to promote the uptake of renewable technologies, including domestic small-scale wind. The level and structure of these payments have not been agreed but are currently under consultation. However, it is likely that with a feed-in tariff customers will receive a payment for each kWh of electricity generated, with an additional payment for electricity exported to the grid. If a national feed-in tariff is adopted, the owner of the turbine would also benefit from using the electricity generated by their turbine and therefore avoiding the cost of purchasing electricity. The total incentive will probably be set higher than the rates currently offered by the energy suppliers and thus should improve the financial viability for potential customers. Specific benefits of a feed-in tariff are expected to include greater transparency and an easier process for customers to sell excess electricity generation, as well as a better opportunity to determine the cost effectiveness of an installation before purchase.

Summary of key findings

1 Building mounted turbines monitored in the field trial were primarily located in urban and suburban locations that were found to have inadequate wind speeds. The poor location of these turbines has significantly impacted the measured performance of such turbines.

2 Free standing turbines installed in the appropriate location with an undisturbed wind resource were seen to have very good performance with annual load factors in some instances in excess of 30 per cent. As such, a properly sited and positioned 6kW rated free standing pole mounted turbine with a similar annual performance would be expected to generate approximately 18,000 kWh per annum.

3 The situation in Scotland was found to be better than the rest of the UK due to a number of factors including higher wind speeds and topography.

a Whilst building mounted turbines exhibited generally poor output due to installations at sites with inadequate wind speeds, those in rural or exposed locations achieved load factors in excess of 5 per cent. The best building mounted site in the field trial was located in Scotland with a load factor of 7.4 per cent.

b Free standing pole mounted turbines, installed in the appropriate location with a clean-air wind resource, were seen to have very good performance throughout the UK, but observed performance in Scotland was exceptionally good due to higher recorded wind speeds. In Scotland, annual load factors in excess of 30 per cent were measured in some instances.

4 Manufacturers' presentation of their power curves and ratings of turbines have been calculated using different methods. Additionally, a number of manufacturers' power curves were deemed inaccurate or incorrect. As such, it is difficult for potential customers to compare the performance of different products. Potential customers should treat published power curves with caution until such time that products receive MCS accreditation.

5 The Microgeneration Certification Scheme (MCS) has developed standards that require manufacturers to publish an accredited power curve. These standards will likely be in force by the end of 2009. Such standards will allow customers to more easily compare predicted performance amongst different products.

6 The NOABL database was found to significantly overestimate the wind resource at urban sites. It should not be used for wind speed estimation unless the site is very remote. The new Microgeneration Certification Scheme installer standard has incorporated an adjustment to NOABL that is now used by accredited installers. This method provides a more accurate prediction of wind speeds than NOABL at domestic locations, especially for urban and suburban sites.

7 The Carbon Trust tool for wind speed estimation was found to be the most accurate method to predict wind speeds at potential sites of both free-standing and building mounted turbines. Estimates at built up and exposed sites were broadly in agreement with in-situ measurements from the field trial.

8 Customer feedback indicates that perception of the technology corresponds closely with technical performance. Customers were more positive about their wind turbines when receiving demonstrable cost and energy savings from their turbine.

9 There is a good market potential for 455,650 small-scale domestic wind turbines in the UK, especially for free standing pole mounted turbines installed in exposed rural locations.

Customer feedback

The Energy Saving Trust conducted a customer feedback exercise to support the findings from the technical field trial. This comprehensive customer feedback exercise was conducted by writing to three groups of domestic wind customers: field trial participants, Low Carbon Buildings Programme (LCBP) grant recipients and Scottish Community and Household Renewable Initiative (SCHRI) grant recipients. Feedback was gathered via an online questionnaire conducted in March and April 2009.

The questions were grouped into three categories to determine the following information:

- The type of turbine, the nature of the installation (urban vs. rural) and the demographics of the participants
- Customer motivation to install a domestic scale wind turbine
- Customer satisfaction with their turbine

A total of 712 customers were contacted to participate in the exercise, including 115 participants in the Energy Saving Trust field trial (this number included both fully monitored sites and energy generation only sites). A total of 360 responses were received, which corresponds to a statistically robust 51 per cent response rate.

A number of notable themes emerged from the analysis of responses. Firstly, an overwhelming number of respondents (85 per cent) installed a wind turbine to reduce their electricity bills. This was the main driver to purchase the technology, followed by a desire help the environment (78 per cent) and to reduce emissions (66 per cent).

Some 49 per cent of respondents claimed they saw a reduction in their electricity bills, and 35 per cent claimed they had seen no reduction since installing their turbine. It must be noted, however, that customers found it difficult to determine the extent of energy/cost savings due to the increases in energy prices.

When commenting on the performance of their turbines, 59 per cent of respondents said their turbine performed reliably, 32 per cent said they perceived their turbine to be noisy and 29 per cent said the turbine caused vibrations. Customers living in rural areas were happier with their turbine than those in urban/suburban areas: 62 per cent of rural respondents would recommend a turbine to a friend, compared with 39 per cent of non-rural respondents.

A large number of respondents expressed difficulties when trying to export excess electricity to the grid. Customers also commented that they were not receiving equitable rates from their energy supplier for any exported electricity, and there were a number of people who had difficulties with the process of claiming Renewables Obligation Certificates.

The results from the customer feedback exercise indicate that customers' perceptions of the technology correspond closely with technical performance of their turbine. Customers were more positive about their wind turbine when receiving demonstrable cost and energy savings. Such demonstrable savings were primarily achieved from turbines in rural locations, and, as such, customers who had purchased free standing turbines in rural areas expressed the most positive feedback. Customers in urban/suburban locations had high expectations from their turbine, but in many instances these expectations have not been met. This is an indication that turbines were installed with claims of potential generation that, due mainly to inadequate wind speeds, have shown to not be tenable in a built up environment.

Customers also expressed the difficulty encountered when trying to sell excess electricity generation to the grid. It is recommended that the energy suppliers provide more comprehensive guidance to existing and potential customers about the process to do so.

Conclusions

The field trial has highlighted a number of areas that industry and policymakers must improve to support effective growth of the industry and provide better information to potential domestic customers. These key areas include the development and enforcement of installation and product standards, improved wind speed prediction and improved site assessment. The Microgeneration Certification Scheme (MCS) will aim to provide customers with the highest level of assurance in terms of product and installers. The Energy Saving Trust has consulted with relevant stakeholders to discuss these improvements and identify future actions to provide better information to potential consumers.

The field trial has shown the need for uniform, industry adopted, installation and product standards for all products. Such standards should ensure that potential consumers are provided with a better indication of turbine performance, are able to easily compare competing products, and receive improved advice by an installer. Standards must also provide consistent performance information to consumers.

The field trial has also illustrated the need for an improved method to predict wind speeds at a potential site. There are now a number of tools – including the Carbon Trust tool and adjusted NOABL – that provide a more accurate prediction than was previously available. Microgeneration Certification Scheme accredited installers must now undertake an assessment of the local wind speed using the adjusted NOABL tool. The Energy Saving Trust will aim to utilise both the adjusted NOABL and Carbon Trust tool to provide advice to potential consumers, but will always recommend that customers install anemometry whenever possible prior to installing a wind turbine. The improved wind speed prediction models will enable consumers to determine, at an early stage, if their location is suitable for a turbine.

The field trial has also shown that local topography and site characteristics can have considerable impact on the available wind resource and turbine performance at a site. As such, fewer sites than previously predicted should be considered suitable to install the technology.

Measured load factors for all building mounted turbines were lower than the commonly quoted figure of 10 per cent. The average measured load factor for free standing pole mounted turbines was 19 per cent, compared with a commonly quoted figure of 17 per cent. The situation in Scotland was found to be better than the rest of the UK. Annual load factors in excess of 30 per cent were measured in some instances for appropriately sited free standing pole mounted turbines in Scotland.

Previous research has provided a number of scenarios suggesting the potential market for domestic small-scale wind in the UK. This study illustrates the market potential of ideal domestic sites, based upon actual on-site performance and wind speed measurements. Our assessment has identified that, at current electricity prices, there is a market potential for 455,650 economic domestic small-scale wind installations across England, Scotland, Wales, and Northern Ireland. Future improvement to product technology and the introduction of feed-in tariffs could increase the market potential for the technology.

The Energy Saving Trust has consulted widely with each of the manufacturers represented in the field trial in the development and delivery of this project. We have seen the industry move along quickly since the field trial was launched in 2007, and, as a result of the field trial, we have seen manufacturers starting to take positive and proactive steps in response to our findings, including improving siting and the information and support available to their customers. These improvements by the industry, in addition to the development of uniform standards, should in future allow consumers to confidently choose the most appropriate product for their specific scenario.

Recommendations for domestic consumers

As a result of the field trial, the Energy Saving Trust has identified a number of recommendations for customers who are interested in purchasing a wind turbine. Customers will be encouraged to contact their local Energy Saving Trust advice centre for more information.

- Domestic small-scale wind turbines do work and can generate energy and carbon savings – but only when installed properly and sited in a location with an unobstructed and appropriate wind resource.
- Customers should consider domestic small-scale wind as one option in a potential suite of microgeneration technologies, and only after they have maximised the energy efficiency of their home.
- Suitable sites can expect to sell excess electricity back to the grid, decreasing the payback time. Payback should improve further once a national feed-in tariff scheme is adopted. Current 'buy-back' rates are available from the Energy Saving Trust's website[16].
- Wind speeds are difficult to predict and highly variable. New prediction tools are improved, but the Energy Saving Trust recommends that, where practicable, potential customers install anemometry to determine their average wind speed over at least three months.
- Customers are advised to always utilise products and installers certified under the Microgeneration Certification Scheme.
- Customers should be aware that a number of manufacturers' performance claims are not yet standardised or comparable. Manufacturers have been supportive of the field trial and have proactively taken steps to improve site identification and support to customers.
- The introduction of improved product and installation standards will mean that information from specific products is easily comparable. Once introduced, potential customers should only consider products that comply with these standards.
- The Energy Saving Trust advice network is able to provide advice to customers to help them determine if a wind turbine may be the right choice. **To contact your local Energy Saving Trust advice centre call 0800 512 012.**

16. http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy

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