UK Small-Scale Wind Survey

Installed Capacity, Annual Generation & Market Growth

Report to
Department of Energy and Climate Change

ED02439
May 2009

Title	UK Small Wind Survey: Installed Capacity & Annual Generation
Customer	Department of Energy and Climate Change
Customer reference	ED45244
Confidentiality, copyright and reproduction	Copyright Department of Energy and Climate Change This report is the Copyright of DECC and has been prepared by AEA Technology plc under contract to DECC dated 13th July 2006. The contents of this report may not be reproduced in whole or in part, nor passed to any organisation or person without the specific prior written permission of DECC. AEA Technology plc accepts no liability whatsoever to any third party for any loss or damage arising from any interpretation or use of the information contained in this report, or reliance on any views expressed therein
File reference	N:\FES\Projects\DTI\RESTATS\RESTATS05\Small wind survey\Report
Reference number	ED45244 – Issue 2

AEA Group
329 Harwell
Didcot
Oxfordshire
OX11 0QJ

t: 0870 190 6092
f: 0870 190 8109

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001 and ISO14001

Author	Name	Tom Willcock Sophie Appleby
Approved by	Name	Steve Dagnall
	Signature	SP Dagnall
	Date	12 July 2012

Executive summary

Interest in microgeneration technologies has been increasing in recent years supported by a number of policy measures, most notably the Governments Microgeneration Strategy 2006. Potentially, such systems including small-scale wind turbines could make a significant contribution towards meeting UK renewable energy targets and climate change goals.

The study gathers data relating to turbines between 0 – 100 kW in order to estimate the number of installations and installed generating capacity at the end of 2008. Also discussed is the likely development of the small-scale wind industry and the possible drivers and barriers that may affect future uptake.

On the basis of available data, it is estimated that there are approximately 14,000 small-scale wind turbine installations up to 100 kW in the UK in 2008, with an installed generating capacity of around 26 MW. 84% of all small-scale turbine units installed in the UK are Micro-Wind Turbines i.e. with a power rating between 0 – 1.5 kW which provide 9 MW of generating capacity. Turbines with a power rating between 1.5 – 10 kW account for approximately 10 MW of generating capacity in the UK.

Electricity generated from small-scale wind has been estimated to be in the region of 16 GWh/yr. This figure is based on a review of recent studies to determine appropriate capacity factors for small-scale turbine generators – previous values are known to have overestimated likely turbine energy output. However the estimated electricity generation is still very uncertain – the value could be as high as 33GWh or as low as 3GWh. As more turbines undergo operational testing in order to achieve industry approved accreditation standards and appropriate siting improves, more accurate estimations of energy output can be made.

In order to offer figures for the number of small-scale wind units by devolved nation, numbers for England, Wales, Scotland and Northern Ireland have been extrapolated. This assumes that the relative uptake of small-scale turbine grants awarded to each country is representative of market share. Using this method, over half of the UK's small-wind turbines are in England with an installed capacity of over 16 MW. Wales, Scotland and Northern Ireland account for approximately 6%, 13% and 23% of units respectively.

The future development of the small-scale wind industry is dependent on a great number of factors and the interplay between market drivers and barriers to growth. Government environmental targets, escalating fossil fuel prices and a call for greater energy security are all serving to promote small-scale wind and boost sales. However, there exist a number of significant hurdles to overcome in order to achieve widespread penetration in the UK.

Table 1: UK Small-Scale Wind Turbine sector summary in 2008

Turbine Size (kW)	Estimated No. of Units	Installed Capacity (MW)	Energy Generated (MWh/yr)[1]
0 - 1.5 kW	11,996	9.0	4,729
1.5 - 10 kW	2,014	10.1	6,175
10 - 20 kW	198	3.0	2,081
20 - 50 kW	47	1.6	1,297
50 – 100 kW	29	2.2	1,905
Total	**14,284**	**25.9**	**16,187**

[1] Assuming 'Average' capacity factor scenario (see Section 3.1)

Table 2: Small-Scale Wind Turbine grants awarded in the UK

	No. of Grants	%
England	1,119	57.6
Wales	117	6.0
Scotland	257	13.2
Northern Ireland	449	23.1
Total	**1,942**	**100**

Table 3: Estimated Small-Scale Wind Turbine sector details by country, based on grant allocations

	Estimated No. of Units	Installed Capacity (MW)	Energy Generated (MWh/yr)[2]
England	8,231	16.6	9,327
Wales	861	1.7	974
Scotland	1,890	3.8	2,142
Northern Ireland	3,303	6.7	3,742
Total	**14,284**	**28.8**	**16,187**

[2] Assuming 'Average' capacity factor scenario (see Section 3.1)

Table of contents

Appendices

Glossary

BEAMA	British Electro-technical and Allied Manufacturers' Association
BERR	Department of Business Enterprise and Regulatory Reform
BRE	Building Research Establishment www.bre.co.uk/index.jsp
BWEA	British Wind Energy Association
Capacity factor (or load factor)	The net capacity factor of a wind turbine is the ratio of the actual output of a wind turbine over a period of time and its output if it had operated at full nameplate capacity the entire time (rated output).
DECC	Department of Energy and Climate Change
EST	Energy Saving Trust
EU	European Union
FIT	Feed In Tariff
GW	Gigawatt, a unit of power (1 GW = 10^6 kW)
GWh	Gigawatt Hour, a unit of energy
HAWT	Horizontal Axis Wind Turbine
Installed capacity	The maximum power available from the turbines operating within a given area. This is usually accumulated from the rated outputs of the turbines.
kW	kilowatt, a unit of power (1 kW = 10^3 W)
LA	Local Authority
Large-scale wind systems	Turbine(s) with a rated power output of 1 MW or greater.
LCBP	Low Carbon Buildings Programme
MCS	Microgeneration Certification Scheme
MW	Megawatt, a unit of power (1 MW = 10^3 kW)
MWh	Megawatt Hour, a unit of energy
Rated output	Power available from a particular wind turbine under given test wind speed conditions. This is usually the maximum power output at higher than average wind speeds, but below extreme wind speeds, where the turbines shut down to prevent wind damage to the turbines. The energy output over a year (MWh) is expressed by the rated output (MW) x capacity factor (or load factor) x 8760 hrs.
RDA	Regional Development Agencies
RESTATS	Renewable Energy STATisticS database (http://www.restats.org.uk/)
SCHRI	Scottish Communities and Householders Renewables Initiative
Small-scale wind systems	Turbine(s) with a rated power output of 50 kW or less, although this study will include all systems 100 kW or less
SSE	Scottish and Southern Energy
UKAS	United Kingdom Accreditation Service
VAWT	Vertical axis Wind Turbine

1 INTRODUCTION

1.1 Aims and Objectives

AEA is pleased to present this report to the Department of Energy and Climate Change (DECC) as part of the Renewable Energy Statistics Database (RESTATS)[3] project regarding the installed capacity and annual generation of small-scale wind turbines. With increasing interest in small-scale wind systems as a means of contributing towards UK renewable energy targets[4], recent studies have attempted to quantify the number of installations in the UK and estimate the energy generating potential of the sector. This study aims to build upon previous research by RESTATS and other organisations in order to address the following:

1. **Research gaps**

Small-scale wind systems are electricity generating microgeneration technology defined as turbines rated up to 50 kW[5]. As such, most studies aimed at quantifying small-scale wind installations and unit sales limit reporting to generators rated up to 50 kW. Research relating to large-scale turbines generally concentrates on machines over 1 MW. Therefore a gap in reporting exists for wind turbines between 50 kW and 1MW. This study aims to reduce this gap by considering all small-scale turbines between 0 kW and 100 kW and updating previous 2006 RESTATS estimates[6].

2. **Discrepancies Regarding turbine capacity factors**

The estimation of energy generation, as calculated in the 2006 RESTATS gap analysis, is based on capacity factors for large-scale wind turbines and over estimates the annual energy yield from small-scale turbines. Since then, there have been a number of studies into the efficiencies of small and micro-wind turbines based on in-situ field testing. This report aims to evaluate recent research to discern appropriate turbine capacity factors under different scenarios and enable a more accurate estimation of energy generation from small-scale systems.

3. **Market growth**

It is apparent from consultation with industry stakeholders for the purpose of this report, that the small-scale wind turbine sector has experienced significant growth in recent years. There are further indications of an industry 'ramp up' with Scottish and Southern Energy's (SEE's) purchase of 2000 Swift turbines for domestic installation, the collaboration of British Gas and Windsave for a similar project and Local Authority initiatives to incorporate microgeneration technology into new builds. This report discusses small-scale wind turbine market development and factors affecting future growth.

Objectives:

- Collate small-scale wind turbine data to estimate the current 2008 baseline for the number of installed units in the UK as a whole and by devolved nation, and expand the scope of alternative industry surveys to include turbines up to 100 kW.
- Evaluate research into small-scale turbine performance and efficiency in order to estimate annual energy generation from small wind systems.
- Discuss market development and identify factors that may affect the future growth of the small-scale wind turbine industry in the UK.

[3] http://www.restats.org.uk/
[4] UK government targets for achieving 15% of energy (including transport) from renewable sources by 2020.
[5] The Climate Change and Sustainable Energy Act 2006 defines microgeneration as up to 50 kW_e for electricity generating technologies
[6] Tipping A. 2006. RESTATS Gap Analysis – Small-Scale Wind Turbines, Department of Trade and Industry (Energy Policy and Analysis).

1.2 About Small–Scale Wind Systems

1.2.1 Turbine characteristics

The Government's Microgeneration Strategy (2006)[7] and BWEA defines small-scale wind systems as turbines rated up to 50kW, which can be sub divided into two categories, micro-wind turbines and small wind turbines. This study will also treat turbines rated ≤ 100 W as a distinct class, which are labelled in this report as 'Tiny Turbines'.

Generally, turbines rated between 50 kW - 100 kW have a power output greater than that technically considered a small-scale wind system. However for the purpose of this report, all turbines with a power rating equal to or less than 100 kW will be regarded as small-scale wind turbines. In order to differentiate between turbines above and below 50 kW, those rated 50 kW - ≤ 100 kW are termed Small Wind Turbines, Class 2. Table 1 provides details of likely characteristics for each class of small-scale wind turbine.

Table 4: BWEA definitions of typical small-scale wind turbine systems

Definitions of Small-Scale Wind Turbines

Tiny Turbines

- ≤ 100 W
- Generally off grid, battery charging units
- Usually mounted directly onto sailboats, remote – homes and dwellings.

Micro-Wind Turbines

- 0 - < 1.5 kW
- Typically with a diameter of less than 2.1m (Swept Area < 3.5m²).
- Tend to be either free-standing or mounted directly to the side or top of the attached building.
- Usually mounted 3-4m above the ridge line of the attached building, or tip height up to approximately 16m above ground level for free standing system setups.

Small-Wind Turbines

- 1.5 kW – 50 kW
- Typically with a diameter of more than 2.1m (Swept Area > 3.5m²).
- Predominantly free-standing although interest in mounting units on top of large residential and commercial buildings is growing.
- Free-standing small wind turbines can reach over 30m in total height (i.e. from the ground to tip of highest blade).

Small-Wind Turbines (Class 2)

- 50 kW – ≤ 100 kW
- Typically with a rotor diameter of 18 – 21 m
- Typical hub height 18 – 35 m.
- Free – standing, serving a range of applications such as isolated communities and commercial premises
- Can be on grid or off grid

Small-Scale Wind Systems can be either…

- Off Grid (12, 24 or 48 Volts) **or** On Grid (240 Volts)
- Building mounted **or** free standing
- Vertical Axis Wind Turbines (VAWTs) **or** Horizontal Axis wind Turbines (HAWTs)
- Single turbine structures **or** integrated microgeneration systems e.g. with photovoltaic technology

[7] http://www.berr.gov.uk/whatwedo/energy/sources/sustainable/microgeneration/index.html)

1.2.2 Market Characteristics

In terms of operational characteristics, siting considerations, the value of the market and the market drivers, small-scale wind systems vary markedly from large-scale units. They also have a greater range of applications compared to large-scale wind turbines and can be either off grid or on grid, mobile or fixed, and can form part of combined installations, most commonly with photovoltaic systems. Small-scale turbines therefore need to be suitable for installation and operation in a diverse range of conditions such as those encountered in the built environment, remote locations, and onboard boats, where the primary purpose of the site is not electricity generation. Table 2 provides an overview of the different market sectors for small-scale wind systems and a description of the likely installation characteristics for each sector.

Whereas large-scale turbines require substantial capital investment and primarily serve the commercial power sector, the predominant customer base for the small and micro-wind market is the domestic sector[8]. Furthermore, the nature of the supply chain for small-scale wind turbines, from technical development, manufacture, distribution and installation, as well as marketing and sales activities, is fundamentally different to that for large-scale generators.

Table 5: Market sectors and applications for small scale wind turbines

Sector	Setting	Outline Description	Tiny Turbines ≤ 100 W	Micro – Wind Turbines 100 W - < 1.5 kW	Small – Wind Turbines 1.5 kW – 50 kW	Small – Wind Turbines (Class 2) < 50 kW – ≤ 100 kW
Sailing / Marine Leisure	- Yachts - Motor boats	Mounted onboard boats usually to charge batteries for lights, computers, pumps etc.	●	●		
Domestic	- Individual Householders - Local Authorities - Housing Associations - Community Groups	Single installations on dwellings; usually building mounted or freestanding micro sized turbines, however some domestic dwellings make use of up to 11kW turbines, or indeed larger depending on onsite resource, demand levels, and financial decisions.	●	●	●	
Commercial	- Supermarkets - Petrol Stations - Universities - Colleges - Leisure Centres	Usually single installations. Micro or Small-Wind Turbines depending on site conditions, demand levels and financing.		●	●	●
Agricultural	- Farmhouses - Farmsteads - Outbuildings	Single installations on farm dwellings and outbuildings; either Micro or Small-Wind Turbines; latter becoming more prevalent.		●	●	
Public	- Public Buildings - Schools - Leisure Centres	Single or multiple installations; micro sized building mounted wind turbines or free standing small sized units where land is available and suitable.		●	●	●
Community	- Isolated Communities - Village Power - Mini grid	Single or multiple installations; free standing small sized units where land is available and suitable.			●	●

[8] The opinion of BWEA and Micropower Council

2 METHODOLOGY

2.1 Data Collection

Up to date and complete data on small-scale systems of the 0 – 100 kW power rating is not readily available and so a variety of sources, as detailed below, were used to ascertain the current installed capacity of small-scale wind turbines in the UK.

2.2 Turbine Numbers

BWEA
BWEA figures are based on all global manufacturers' records of sales to the UK from 2005 to 2007 for turbines rated 50 kW or less. Market projections have been made for 2008 and 2009 based on 2005 – 2007 sales growth, and 2008 projections are used in this report. These figures are considered the most accurate estimate to date for turbines of this scale.

Sales Figures
For tiny turbines rated 100 W and under, accurate numbers of installed units are difficult to verify. As a result, data was requested from manufacturers themselves. Originally it was intended that an estimate of the number of Tiny Turbines operational in the UK would be made through discussions with the three main manufacturers of turbines of this class. However, due to their limited response, the results are considered inaccurate and have not been included.

The number of turbines rated 50 - ≤ 100 kW operational in the UK was established through discussions, where possible, with the manufacturers of this class of turbine. Most of these companies are based outside the UK and therefore UK distributors were also approached and data was cross-referenced with BWEA onshore wind statistics.

RESTATS Database
The existing RESTATS database provides information relating to the current installed capacity of turbine units up to 100 kW in the UK and discrete figures for Tiny Turbines and Small Turbines – Class 2, which are not provided by BWEA. Sales figures and BWEA estimates have also been cross-referenced against the RESTATS data to discern any misreporting.

As a result of the limited response from Tiny Turbine manufacturers, figures for this class of unit have been provided by RESTATS. However, these results depart significantly from other estimations e.g. BWEA, and are discussed separately.

Grant Programmes
Although information is available regarding the UK small-scale wind turbine sector as a whole, little data exists to allow definitive figures for the distribution of units installed by devolved nation. This study has used the most recently available uptake figures from grant programmes to extrapolate turbine installations in England, Wales, Scotland and Northern Ireland.

2.3 Capacity Factors

Literature Review
A review of all previous and on-going research into how turbines perform in practice has been undertaken to determine the most likely capacity factors and calculate the UK's annual energy generation from small-scale wind.

2.4 Energy Generation

UK energy generation from small-scale wind turbines of different power ratings has been calculated using the number of turbines installed in each category, average power rating of each turbine category in kW and the appropriate capacity factor for that turbine category. The total energy generated in the UK from small-scale wind turbines 0 – 100 kW is the sum of the energy generated from all small-scale turbine categories.

Energy Generated = (Avrg. rated capacity of each turbine class x No. of turbines in class) x Capacity factor of turbine class x 8760 (hours in a year)

2.5 Market Growth

Industry Consultation
Industry stakeholders, including manufacturers, suppliers, BWEA and the Micropower Council were approached to provide insight into the likely development of the small-scale wind industry, and factors affecting future market growth.

3 RESULTS

3.1 Capacity Factor

The 2006 RESTATS Gap Analysis report[4] estimated the annual electricity generation from small-scale systems using the capacity factors from information provided by BRE and the Clear Skies grant programme (see Appendix 3 for details). These figures are based on capacity factors for large-scale wind turbines and at the time it was acknowledged that energy output calculated using these capacity factors are likely to be overestimates.

Table 6: Capacity Factors used in RESTATS 2006 report

Country	Capacity Factor
Northern Ireland	0.34
Scotland	0.29
England	0.27
Wales	0.25

A report by the Energy Saving Trust (EST)[9], which evaluated the best ways of accelerating the growth of preferred microgeneration technologies, modelled the capacity factor in an urban and rural environment as 0.10 & 0.17 respectively. A recent report by BWEA[10], which assessed the current size and dynamic of the UK small-scale wind system sector, has used the same capacity factors (Table 4). This assumes that all the turbines (up to 1.5 kW in unit size) are installed in an urban environment and all the turbines (1.5 - 50 kW) are installed in a rural environment.

Table 7: BWEA Capacity Factors

Unit Size	Capacity Factor
0 - 1.5 kW	0.10
1.5 - 10 kW	0.17
10 - 20 kW	0.17
20 - 50 kW	0.17

Up until recently the performance of small-scale wind energy systems has been based on theoretical results from manufacturer's tests. Several field trials have now been completed that try to demonstrate how well small-scale turbines perform in practice.

The objectives of the Warwick Wind Trials[11] were to see how grid connected small-scale wind turbines performed on a variety of building types. These turbines were mounted on sites ranging from theoretically poor (single storey urban buildings) through to theoretically excellent (45m tall exposed flats in isolated settings on hilltops). After 168,950 hours of operation of 26 wind turbines from five manufacturers across the UK during 2007-2008 the conclusions are summarised in Table 5.

[9] Generating the Future: An analysis of policy interventions to achieve widespread microgeneration penetration. 2007. Energy Saving Trust
[10] BWEA Small Wind Systems UK Market Report 2008
[11] Warwick Wind Trials. 2009. Encraft

Table 8: Warwick Wind Trials: Capacity Factor

In-Use Capacity Factor	Range	Average Capacity Factor
Perfect[12]	0.0029 - 0.1654	0.0415
Actual[13]	-0.0086 - 0.0332	0.0085

The report states that the Actual In-Use Capacity Factor figure, while low, is probably the most realistic for planning projects, as the turbines on the trial were not turned off unless this became unavoidable. Downtime reflects real in-use problems, and appears to be inherent in the technology at this stage of development.

Following on from the Warwick Wind Trials the Carbon Trust has developed an on-line Wind Power Estimator[14] specifically for small-scale systems. The tool will enable the user to estimate the local annual mean wind speed at a chosen location in the UK and the annual yield and carbon savings of a small-scale wind turbine. It is important to understand that the tool's estimates are based on a simplified model of wind speeds and local physical conditions. Due to the lack of field test data at the time of writing, it is not possible to empirically verify the tool's methodology and results.

A Technology Strategy Board project by BEAMA[15] also monitored the electricity generated by small-scale wind turbines (<20 kW). The project found that the average capacity factors varied widely. Values ranging from 0.15 down to below 0.01 were recorded. The average capacity factor was 0.078.

The EST are currently running field trials[16] for small-scale wind turbines to determine energy generation and carbon savings, identify factors that influence performance of micro-wind systems, evaluate inverter performance and to provide independent information to the consumer. By the end of April 2009 the EST plan to have created a new diagnostic tool[17] that will help consumers identify the best microgeneration technologies for them. The EST will issue a public report summarising the finding of the field trials report by mid-May 2009.

To date, there is limited evidence of the performance of small-scale wind turbines in certain locations, particularly in urban / built-up areas. The performance of a small-scale wind turbine is largely affected by two variables: the on-site wind resource and the accuracy of the turbine rating as claimed by the manufacturer. If either of these two factors is not as expected, the annual energy yield (and overall capacity factor) can be greatly affected.

It is hoped the Carbon Trust and EST tools mentioned above will help individuals and developers to appropriately site turbines. There are also schemes in place to independently check the accuracy of the turbine rating. One such scheme is the Microgeneration Certification Scheme[18] (MCS). The primary aim of the MCS is to provide consumers with confidence and protection by guaranteeing that microgeneration products and installers who carry the mark meet, and will continue to meet, robust quality standards.

In order to provide an estimate of electricity generation from small-scale wind turbines, we propose to use different scenarios modelling a variety of wind turbine siting success. Table 6 illustrates the capacity factors that we have estimated to represent the various siting scenarios.

Table 9: Capacity Factor of Siting Scenarios

Siting Scenario	0 – 1.5 kW	1.5 kW – 10 kW	10 – 20 kW	20 – 50 kW	50 kW – 100 kW
Excellent	0.11	0.13	0.15	0.17	0.19
Average	0.06	0.07	0.08	0.09	0.1

12 Perfect in use capacity factor - The given time period only includes those times when we know turbines were switched on. Imported energy is ignored.
13 Actual in use capacity factor - The given time period includes times when turbines were switched off and imported energy is subtracted from the generation total
14 http://www.carbontrust.co.uk/windpowerestimator/WindPowerEstimatorTerms.aspx
15 Parsons, J. 2008. Metering and Monitoring of Domestic Embedded Generation, BEAMA
16 http://www.warwickwindtrials.org.uk/resources/Jaryn+Bradford+-+Energy+Saving+Trust.pdf
17 http://www.energysavingtrust.org.uk/Generate-your-own-energy
18 http://www.microgenerationcertification.com/

Poor	0.01	0.01	0.01	0.01	0.01

It is important to note that the above capacity factors are not a reflection on the intrinsic performance of small-scale wind turbines, but rather an indication of the current ability to appropriately site them. As the output of a wind turbine is directly dependent on a locations wind resource, turbulence and sheltering, the recently launched EST and Carbon Trust tools should ensure better screening of potential sites. As a result, turbines with proven and certified performance should be better located, and hence more accurate capacity factors can be used to calculate likely energy output.

3.2 Turbine Numbers

From the information gathering exercise, it is estimated there are **14,284** small-scale wind installations up to 100 kW in the UK in 2008, with an installed generating capacity of approximately **25.857 MW**. Figures 1 and 2 present a breakdown of total number of installations by size category. Figures 3 and 4 present a breakdown of total installed capacity by size category.

Figure 1: Estimated number of installed UK small wind systems

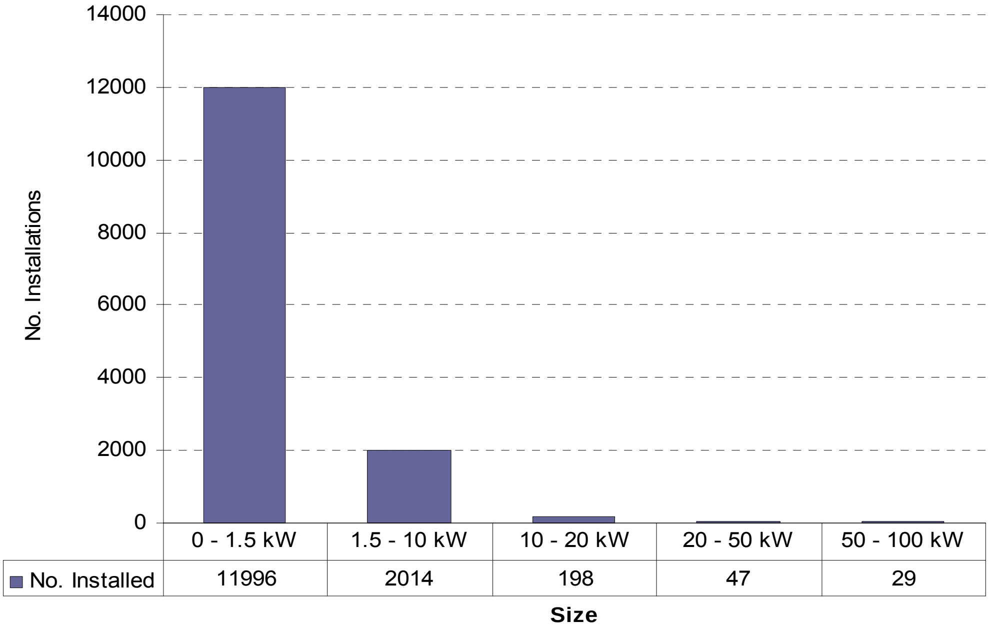


Figure 2: Proportion of turbines of each class

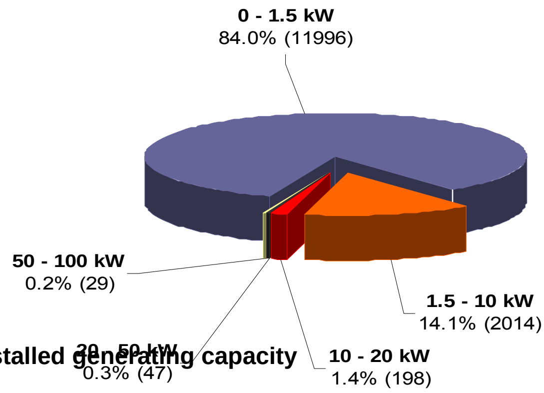


Figure 3: Estimated installed generating capacity

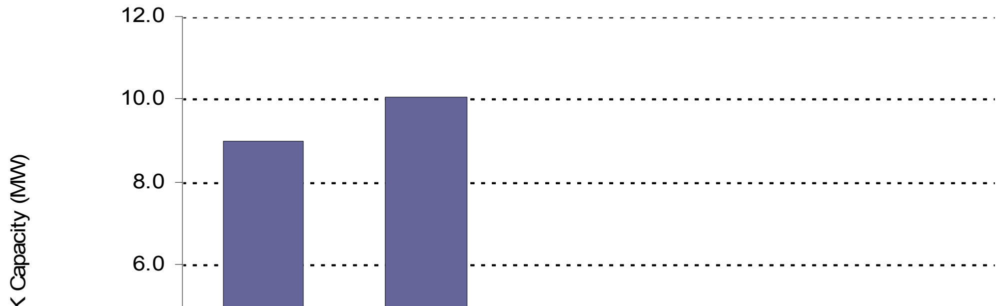
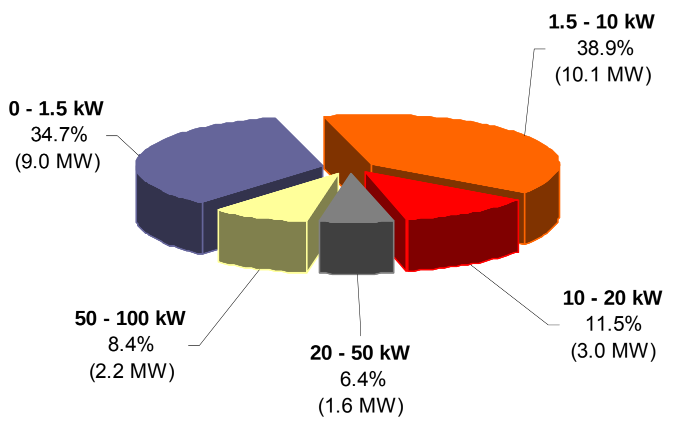


Figure 4: Proportion of energy generated by turbine class



As can be seen from Figure 2, the majority (84%) of installed units in the UK are Micro-Wind Turbines, accounting for nearly 9 MW (34.7%) of energy generating capacity. Although 1.5 – 10 kW turbines account for 14.1% of total number of units, they make the greatest contribution to generating capacity (10.1 MW). As previously mentioned, turbines of the size range 50 – 100 kW are often omitted from microgeneration research, as they are not considered small-scale wind turbines. Although they only constitute 0.2% of the overall number of units 0 – 100 kW, machines of this class provide 2.2 MW of installed capacity.

Tiny Turbines

It is not possible to estimate the number of Tiny Turbine units in the UK from up-to-date sales data due to the limited response from manufacturers. The RESTATS database approximate there are about 22,000 Tiny Turbines in the UK and an industry expert commented this may be a reasonable estimate, but numbers are inherently difficult to verify. However, this figure does depart significantly from BWEA projections[19] and as a result, it is not considered appropriate to offer analysis of Tiny Turbines as a distinct category.

3.2.1 Energy generation

Table 7 summarises the estimated energy generated in 2008 from turbines rated 0 – 100 kW in the UK, as modelled on three scenarios for turbine efficiency (Table 6). Based on the 'Average' scenario and the number of units installed in 2008, it is estimated the UK small-wind turbine sector supplies **16,187 MWh**

[19] BWEA predict 11,996 Micro-Wind Turbines (0 – 1.5 kW) were installed in 2008

per annum. Total domestic electricity consumption in the UK is estimated as 118,180 GWh/yr[20]; therefore small-scale wind energy supplied approximately 0.01% of the domestic electricity consumed in the UK in 2008, equivalent to approximately 3,804[21] homes.

Table 10: Scenarios for UK small-scale wind turbine energy generation in 2008

Siting Scenario	0 – 1.5 kW	1.5 kW – 10 kW	10 – 20 kW	20 – 50 kW	50 kW – 100 kW	Total
Excellent	8,670 MWh	11,468 MWh	3,901 MWh	2,450 MWh	3,620 MWh	30,109 MWh
Average	**4,729 MWh**	**6,175 MWh**	**2,081 MWh**	**1,297 MWh**	**1,905 MWh**	**16,187 MWh**
Poor	788 MWh	882 MWh	260 MWh	144 MWh	191 MWh	2,265 MWh

BWEA estimates 32,377 MWh of electricity were produced in 2008 from small-scale wind turbines. This is obviously considerably higher than output estimates in this study due to the higher capacity factors used to calculate electricity generation (see Section 3.1).

3.2.2 Turbines by country

Table 8 presents the numbers of grants awarded to England, Wales, Scotland and Northern Ireland for small-scale wind turbine projects under different UK grant programmes. Further details of the main grant programmes are provided in Appendix 3. The information presented is that most recently available from grant databases or administrators at the time of writing. However it should be noted that methods and dates of reporting differ between schemes which potentially introduces error. In addition, grants are generally awarded to microgeneration schemes up to 50 kW and therefore do not reflect turbines of the 50 – 100 kW category. Element Energy's report 'Numbers of microgeneration units installed in England, Wales, Scotland and Northern Ireland' 2008, uses a similar approach to determine installation numbers by country and proposes an accuracy of ± 25% should be applied to all results (numbers installed, kWh generated etc.) derived using this methodology.

Table 11: Installations of small-scale wind turbines under UK public grant schemes at the end of 2008.

Grant Programme	England	Wales	Scotland	N. Ireland	UK
Clear Skies	325	32	0	116	473
LCBP1 - households	541	66	51	16	674
LCBP1 - communities	78	4	0	8	90
LCBP1 - stream 2a	157	13	16	9	195
LCBP2	18	2	2	1	23
SCHRI			188		188
Reconnect				267	267
PBSP (WERB)				26	26
PSPB (LEADER)				6	6
Total public installations	1119	117	257	449	1942
% of grants awarded	**57.6%**	**6.0%**	**13.2%**	**23.1%**	**100%**

The number of installed units in England, Wales, Scotland and Northern Ireland can be extrapolated assuming the relative uptake of small-scale wind turbine grants awarded to each country is representative of market share. Table 9 summarises estimates of capacity installed and energy generated for each UK country modelled on relative grant uptake.

[20] http://stats.berr.gov.uk/energystats/et5_5.xls
[21] Regional and Local Authority Electricity Consumption Statistics, DECC, 2007.

Table 12: Small-scale wind market by country

	England	Wales	Scotland	N.Ireland	UK
Estimated No. of Units	8,231	861	1,890	3,303	14,284
Installed Capacity (MW)	16.62	1.73	3.81	6.67	28.856
Energy Generated (MWh/yr)[22]	9,327	974	2,142	3,742	16,187

3.3 Market Growth

3.3.1 Market drivers

BWEA[23] and RESTATS agree with the views of industry stakeholders consulted that the small-scale wind sector has experienced significant growth in recent years. This has been, and still is, predominantly driven by:

- Escalating fossil fuel prices
- Government policy and legislative measures supporting microgeneration technologies, as listed in Appendices 2, 3 and 4.
- Increasing household numbers
- UK Government CO2 reduction targets

With high current energy prices and greater provision of public grants, there is a rising awareness and growing demand for small-scale wind energy amongst UK households. Previously small-scale wind turbines were predominantly installed on educational institutions and were of the 2 – 2.5 kW category. However, since the small-scale wind energy industry has started to focus on developing the Micro-Wind Turbine sector (0 – 1.5kW) for building integrated installations, the domestic sector has been considered the main market driver. There has been increasing interest in roof-mounted turbines for the urban environment but with a greater wind resource in rural settings, it is the rural domestic sector that is expected to see the greatest market growth.

3.3.2 Barriers to growth

1. Planning Restrictions

All those consulted agreed that planning restrictions present the greatest barrier to market growth of the small-scale wind industry, even though the General Permitted Development Order introduced on the April 6th 2008 lifted the requirements for planning permission for most microgeneration technologies in England.**[24]**. This is due to the fact that noise impacts are associated with small-scale wind turbines and compliance with the Microgeneration Certification Scheme (MCS) or BWEA Performance and Safety Standard will be a prerequisite for Permitted Development for both the turbine and installer. The government must notify the European Union in order to use the MCS standard, which will not occur until drafting of the new Statutory Instrument is complete.

The Welsh Assembly Government, Scottish Government and Northern Ireland Government are currently all considering changes to their legislation on permitted developments, to facilitate installations of microgeneration technologies. Legislation is expected in all three countries later in 2009.

For turbines above 1.5 kW, or those that do not meet the requisite criteria of a Permitted Development, planning permission is still required. The national Governments are yet to release technical planning guidance on small-scale wind turbines and it was the opinion of stakeholders consulted that planning authorities have not been appropriately instructed on how to differentiate planning requirements for

[22] Assuming 'Average' capacity factor scenario
[23] BWEA Small Wind Systems UK Market Report 2008
[24] http://www.lowcarbonbuildings.org.uk/info/permitted/

small-scale installations and large-scale turbines. As such, planning authorities have neither the technical expertise nor the resources to adequately manage an increasing demand for small-scale wind installations, which has led to uncertainties and significant delays in planning decisions.

2. Financial Support Mechanisms

In order for UK manufacturers to meet growing demand and anticipated industry growth by increasing production and expanding their product range, companies are seeking financial assistance from government and RDA's. Manufacturers, distributors and other stakeholders consulted feel that the level of support in the UK at present is insufficient to match the costs associated with an industry upscale. This is not the case in other European countries whose governments are offering comparatively generous funding to UK companies, some of which are considering offers from EU states to move their businesses operations and manufacturing bases abroad.

A feed in tariff (FIT)[25] is expected in April 2010. Similar FIT's have proved successful in other European countries such as Germany and served to boost the uptake of renewable energy by shortening the payback period on investment. The success of a FIT in the UK however will depend on whether the tariff rate is set at an appropriate level.

A recent report[26] commissioned by BERR (now DECC) as part of the Microgeneration Strategy, revealed that installation costs present a considerable barrier for small-scale wind turbines with consumers placing a lower value on ongoing energy costs compared with upfront capital costs. Germany has addressed this issue by offering a loan scheme in conjunction with its FIT, which is sufficient to offset loan repayments. The DECC report 'The Growth Potential for Microgeneration in England, Wales and Scotland[27] suggests a method to offset the capital costs of the installation and further encourage uptake in the form of 'deeming'. Deeming involves bringing forward the annual FIT payments so that support is front-loaded and directly contributes towards the initial cost of installing a turbine.

3. Certification Costs

In order for a turbine model to become BWEA or Microgeneration Certification Scheme certified it must be assessed by a UKAS accredited certification body, meet a set of strict criteria and undergo 2500 hours of operational testing. Details of certification are provided in Appendix 4. This is a robust standard deemed fit for purpose by the small wind turbine industry, state officials, scientists and consumers. However, relative to the size of the market at present, the certification procedure is expensive and costs in the region of £40,000 - £100,000 per turbine model. Moreover, if a technical modification is made to a turbine product, it must be reassessed in order to maintain certification and the manufacturer must again bear the cost of this.

The US, Australia, and some EU States, including Ireland, Spain, and France, are supporting manufacturers financially by providing subsidies or funding for the cost of product certification. The UK offers no such support and although the market is growing rapidly, it remains at present a small-scale sector and therefore the relative cost of certification is significant and often too costly for small companies.

4. Lack of available information

Some consulted felt there was a lack of unbiased information easily accessible to the general public for all microgeneration technologies, and efforts to debunk misconceptions relating small-scale wind turbines were considered ineffective. Micro and Small Wind Turbines are a discretionary purchase so in order for uptake to progress from early adopters to mass-market penetration, consumers must have an understanding of the real costs and benefits to them. One measure developed to address this is the Carbon Trust's Wind Yield Estimation Tool launched on March 5th 2009[28]. The online tool allows users to calculate the annual yield and carbon savings of a small-scale wind turbine based on the local annual wind speed and obtain initial quantitative estimates of the sites potential. A similar measure is new

[25] A feed-in tariff (FIT) is a duty on energy companies to pay a **guaranteed premium** price for electricity generated by renewable sources and exported to the National Grid. If the FIT is set at the correct rate, this provides a better, guaranteed and long term return on investment.
[26] The growth potential for Microgeneration in England, Wales and Scotland, June 2008, Element Energy
[27] The growth potential for Microgeneration in England, Wales and Scotland, Main Appendix, Element Energy, June 2008
[28] http://www.carbontrust.co.uk/windpowerestimator/WindPowerEstimatorTerms.aspx

diagnostic tools created by the EST[29] that will also help consumers identify the best microgeneration technologies for them. The hope is that such tools will lead to better siting of small-scale wind turbines and therefore greater energy generation.

[29] http://www.energysavingtrust.org.uk/Generate-your-own-energy

4 CONCLUSIONS

It is estimated there are 14,284 small-scale wind installations up to 100 kW in the UK in 2008, with an installed generating capacity of approximately 25.857 MW. This equates to an estimated energy output of about 16 GWh/yr although this estimate is extremely uncertain as there is very little data on output – it could be as low as 3 GWh/yr. Micro Turbines (0-1.5 kW) and Small Turbines up to 10 kW provide the greatest contribution (98.1% cumulatively). Although there are relatively few turbines of the category 50 – 100 kW (0.2 %), due to their greater power output compared to traditional small-scale wind turbines, this class provides an estimated 8.4% of energy generation.

Using issued grants as means of estimating turbine numbers in each UK country; it is assumed England has the largest proportion of turbines, producing approximately 10,000 MWh of electricity. Comparatively, turbines in Scotland provide approximately 2,000 MWh of energy. Scotland however has a slightly higher wind resource in relation to UK averages[30], and therefore is well placed to capitalise on an industry growth.

Over the next five years, small-scale wind turbine sales are expected to expand from 8,966 sold in 2008 to over 68,000 in 2013. Therefore in 2013 it is estimated there is likely to be over 191,000 units between 0 – 100 kW installed with a combined capacity of over 382 MW, generating approximately 234 GWh of electricity per annum.

If market growth reflects BWEA projections, small-scale wind technology is likely to become embedded in household and business approaches to energy usage and onsite generation. Over the last few years industry has responded to increased consumer demand for green products and the UK is now recognised as a leading manufacturer for small-scale wind systems[31] and therefore well positioned to promote micro and small-wind technology.

Considering the current capacity of small-scale turbines installed in the UK and the encouraging feedback from industry experts, there is clearly scope for sector expansion for manufacturers, suppliers and installers.

The most significant market sector expansion is likely to be the rural environment where there is a greater wind resource; manufacturers were of the opinion that the agricultural locations offered greatest potential. In addition, domestic and public housing, off grid activities and building integrated renewables for the commercial sector are markets also expected to expand.

The development of small-scale wind industry will however depend on future planning policy, the availability of financial support for the supply chain and end users, as well as the provision of accessible, unbiased information.

[30] Based on the UK wind speed database, derived using the NOABL model
[31] BWEA consultation

5 RECOMMENDATIONS

- Turbines between 50 – 100 kW are not technically considered small-scale, and there are relatively few installations in the UK. Although sales of turbine models of this type have declined in recent years as manufacturers have scaled up machines to capitalise on better economies of scale, current installations provide a notable contribution in energy generation. Therefore, reporting on turbines between 50 – 100 kW, and indeed up to 1MW, should not be overlooked.

- It is difficult to determine the accuracy of sales data provided by manufacturers and co-operation from individual companies differs. In future, a collaborative approach from industry stakeholders would help ensure that estimations are as accurate as possible.

- There has been a lower response rate compared with the previous survey, because it transpired that the British Wind Energy Association (BWEA) have also been conducting a survey amongst the same respondents. BWEA data has not been used directly to determine electricity generated, as AEA apply different capacity factors. However, it is suggested that AEA work more closely with BWEA in the future to overcome these difficulties. DECC has offered to participate in discussions with BWEA to ensure that the best information is available for use in the official statistics.

Appendices

Appendix 1: Main UK Grant Programmes

Clear Skies Scheme

The Clear Skies Programme ran between 2002 and 2007 and issued £10m worth of grants for solar thermal, biomass boilers, pellet stoves, micro-hydro, ground source heat pumps and wind. It covered the whole of the UK. The scheme issued 316 community installation grants to the value £5.5m and 6633 household installation grants to the value £4.2m[32]. The Low Carbon Buildings Programme has since replaced the scheme.

The Low Carbon Buildings Programme (LCBP)[33]

The LCBP is a UK wide scheme replacing the previous DTI Clear Skies Scheme, and offers capital grants for the installation of MCS certified (Table 3) microgeneration technologies including small-scale wind installations over four years. The scheme was launched in two phases. Phase 1 began in April 2006 and covers the provision of grants to householders and the public and commercial sector. Phase 2 was launched in December 2006 after a further £50 million was committed to supplement the original LCBP budget of £30 million.

Phase 1 of the LCBP consists of 2 streams. Stream 1 covers grants to householders for individual dwelling installations and provides a maximum of £1,000 per kW of installed capacity, subject to an overall cap of £2,500 or 30% of the relevant eligible cost, whichever is lower. Stream 2 ran from September 2006 – September 2007 and provided grants for larger public and commercial installations. It was split into 2 categories, Stream 2A and Stream 2B. Stream 2A provided a maximum grant of £100,000 or 40 – 50% of total installation cost whilst Stream 2 offered up to £1 million or 40 – 50% of installed costs.

Phase 2 provides grants to large public sector and charitable organisations and was launched in December 2006. In April 2008 grant levels were revised after it was identified that upfront costs remained a barrier to uptake. Since then, Phase 2 offers up to 50% of the total installation cost of a turbine. Table 8 figures are based on current statistics provided by BERR and relate to the number of grants committed, referring to currently live or successfully completed grants only.

Scottish Community and Householders Renewables Initiative (SCHRI)[34]

SCHRI is funded by the Scottish Government and offers grants for small wind systems to householders and communities in Scotland. In order to get a SCHRI grant both the individual product and the installer need to be accredited under MCS. For historical reasons there are also a small number of products and installers that have been accredited by the Energy Saving Trust and these are also eligible for funding.

The Householder Stream provides grants to householders of up to 30% of the costs to a maximum of £4,000 for accredited installations. At the end of 2008, a total of 157 grants had been allocated under the Householder Stream.

The SCHRI Community Stream provides grants of up to £100,000 for communities and has a network of development officers who can provide support and advice to communities throughout the installation process. At the end of 2008, 31 grants had been allocated under the Communities Stream.

Therefore, a total of 188 grants have been issued under SCHRI by the end of 2008. These figures have been provided by the Energy Saving Trust who jointly manages the scheme with Community Energy Scotland. It must be noted however, that some wind turbines offered a grant under the Community stream may be larger than 50kW, and in some cases the grant offered might have covered more than one wind turbine.

[32] BERR, Clear Skies Final Report
[33] http://www.lowcarbonbuildings.org.uk/home/
[34] http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-Community-and-Householder-Renewables-Initiative-SCHRI

Reconnect[35]

This is a microgeneration grant scheme in Northern Ireland with a budget of £8m to provide up to 50% of the cost of installation of a solar thermal, photovoltaic, wind unit or biomass boiler. Approximately 1,300 installations have been installed in total to date (end 2008) – mostly solar thermal.

[35]http:// www.reconnect.org.uk/

Appendix 2: Measures supporting microgeneration technology

The Governments Microgeneration Strategy, 2006[36]

In March 2006 the government launched the Microgeneration Strategy. The Strategy sets out 25 actions to address the barriers to widespread uptake of microgeneration technologies and addresses five sets of constraints listed below. All but action 16 and 20 have been completed. According to the Microgeneration Strategy Progress Report, June 2008[37], the UK now has a greater understanding of the microgeneration market as a result of the Strategy which has served to raise awareness and increase uptake. However, it also recognises that more can be done to develop the future market for all microgeneration technologies, including small-scale wind.

Cost Constraints
Actions to address:

1. Research into consumer behaviour
2. DECC to publish details of how the extra £50m LCBP money will be spent·
3. Guidance covering ROCs, LECs and REGOs[38]
4. DECC to respond to two reports published by the Distributed Generation Coordinating Group (DGCG) on the accrual of ROCs, LECs and REGOs
5. Energy suppliers to develop a scheme to reward microgenerators exporting excess electricity
6. Defra to look at including electricity generating technologies in EEC

Information Constraints
Actions to address:

7. Development of Certification scheme
8. Review of consumer information
9. Investigate possibility of microgeneration on DECC estate
10. Information needs of planning officers
11. Energy measures report for local authorities
12. Communications package for construction industry

Technical constraints
Actions to address:

13. Networks developed to accommodate more microgenerators exporting electricity
14. Contracts with electricity companies not hindering take-up of microgeneration
15. Wiring regulations not forming a barrier to uptake
16. Investigate possibility of field trial for smart meters
17. Examine recommendations in report on technical barriers

Regulatory constraints
Actions to address:

18. View about facilitating microgeneration in General Permitted Development Order (GPDO)
19. Urgent review of local plans for inclusion of PPS22 policies

Other Actions:

20. Develop a scheme for installing microgeneration in schools
21. Research into future potential of microgeneration to help inform decision on targets
22. Map of R & D funding
23. Route maps for each technology
24. Explore with Sector Skills Councils what more can be done to ensure a skills base develops
25. Ofgem decision document on their consultation

[36] http://www.berr.gov.uk/energy/sources/sustainable/microgeneration/strategy/page27594.html
[37] http://www.berr.gov.uk/energy/sources/sustainable/microgeneration/strategy/page27594.html

Other measures encouraging microgeneration uptake:

- Government legislation that all new homes will be zero carbon by 2016[39].
- Government legislation that all new non domestic buildings will be zero carbon by 2019 and all new public sector buildings to be zero carbon by 2018.This is in addition to Government's earlier commitment that all new schools are zero carbon from 2016[40].
- Zero carbon homes of the value up to £500,000 are exempt from stamp duty payments[41].
- Government amendments to the Renewables Obligation in April 2007 to make it easier for microgenerators to participate by allowing an agent to act on their behalf. This allows the output of a number of small wind turbines to be combined and therefore more worthwhile for microgenerators to be involved even when they generate very small amounts of electricity[42].
- Microgenerators are exempt from tax on any income they get from the sale of surplus electricity to the grid or from ROCs and certified small-scale wind installations benefit from a reduced rate of VAT (5%).[43].

- Under the Carbon Emissions Reduction Target (CERT) (2008 – 2011), whereby energy suppliers must deliver measures that will provide overall lifetime CO2 savings of 185 MtCO2 by 2011 by boosting householder energy efficiency.[44]
- The government announcement at pre-Budget report 2007 that microgeneration investments will not be included in ad hoc re-assessments of business rates liability from 2008.
- The Energy Act 2008 made provision for a system of feed-in tariffs to be introduced for small-scale renewable generators (e.g. small-scale wind turbines) up to a maximum total capacity of 5MW, to incentivise households, businesses, and community groups to generate low-carbon electricity. The Government intends to consult in summer 2009 on the detail of a feed-in tariff mechanism, and is aiming to introduce the new mechanism in 2010.
- The Renewables Obligation Order (ROO) (and equivalent legislation in Scotland and Northern Ireland) changes the RO to make it easier to for microgenerators to access the benefits of the RO by placing microgeneration projects in the same technology bands as large scale generation, simplifying the administrative process[45].
- The UK Government's 'Act on CO_2' advice service to provide information on small-scale wind installations as well as other carbon saving information in order to promote uptake[46].

[39] Department for Communities and Local Government, Building a Greener Future, policy statement, 2007 (www.communities.gov.uk/publications/planningandbuilding/building-a-greener)
[40] Department for Communities and Local Government, Definition of Zero Carbon Homes and Non-Domestic Buildings: Consultation, 2008
[41] http://www.hmrc.gov.uk
[42] http://www.berr.gov.uk/energy/sources/sustainable/microgeneration/strategy/implementation/certificates/page39834.html
[43] BERR (now DECC) report Government Response to Report Commissioned by the Distribution Generation Programme on the Accrual of ROC's, LEC's and REGO's, 2008
[44] http://www.defra.gov.uk/environment/climatechange/uk/household/supplier/cert.htm
[45] http://www.berr.gov.uk/files/file39497.pdf
[46] http://actonco2.direct.gov.uk/index.html

Appendix 3: Small-scale turbine certification

Microgeneration Certification Scheme (MCS)[47]

Initiated under the Governments Microgeneration Strategy, the MCS was implemented in 2007 to promote consumer confidence by ensuring microgeneration products, including small-scale wind turbines, meet consistent criteria and quality standards. There are over 400 installers registered, 180 of which have been assessed and over 50 certificates have been issued since February 2008. Installers are required to sign up to a Code of Practice, which meets guidelines set by the Office of Fair Trading's Consumer Code Approval Scheme. The MCS is linked to the BWEA Small Wind Turbine Performance and Safety Standard and a company must meet BWEA standards as well as additional standards specified under the MCS before becoming certified.

BWEA Small Wind Turbine Performance and Safety Standard[48]

Under this standard, certification is granted to manufacturers who meet specific criteria relating to performance, acoustics, strength and safety, durability and manufacturing facility standards. Turbines are required to undergo 2500 hours of testing in operational conditions to ensure turbine models meet technical criteria in terms of performance and safety and the energy output and power rating as claimed by manufacturers has been independently verified by a UKAS accredited certification body. This guarantees products are designed to the best practices accepted in wind energy engineering and allows customers to compare products like for like.

Canada, the USA, the UK, Netherlands, and other EU countries have adopted the BWEA Small Wind Turbine Performance and Safety Standard. The IEC 61400-2 is the current international standard for small wind turbine generators developed by the International Electro-technical Committee. Currently, the IEC 61400-2 Committee is considering adopting the BWEA standard in place of the current IEC 61400-2 standard as an internationally recognised industry measure specifically designed for small-scale wind applications.

[47] http;//www.microgenerationcertification.org
[48] http://www.bwea.com/small/standard.html

AEA

AEA group
329 Harwell
Didcot
Oxfordshire
OX11 0QJ

Tel: 0870 190 6092
Fax: 0870 190 8109