Domestic Roof-Mounted Wind Turbines

The Current State of the Art

A Publication for the RES-e Project

mid wales energy agency
asiantaeth ynni canolbarth cymru

Introduction

The political, media and economic climate for renewables is in a state of rapid flux. Public awareness of global warming and the consequent climate change is growing. The need to increase the use of sources of energy which minimise the deleterious effects of greenhouse gases is pressing. It is this context which makes the development of small-scale renewable generating plant (micro-generation) so exciting. The effect of millions of small micro-generators across the country, in domestic dwellings, businesses and public buildings, has the potential to meet much of the national demand for electricity at source. Further benefits are obtained from micro-generation, as losses due to centralised generation, transmission and distribution are virtually eliminated. Not only does this allow deferment of electricity grid upgrade, but the Carbon Dioxide savings are virtually doubled, as the electricity which arrives at its end point of use has lost roughly 50% of its initial raw energy value from efficiency losses along the way.

A recent study by the Green Alliance (www.green-alliance.org.uk/publications/PubSmallOrAtomic) compared the benefits of investing in micro-generation rather than a new round of nuclear power stations, and concludes that micro-generation is a cost-effective, low-carbon alternative to nuclear power. Renewable energy sources are most effective when there is an intelligent mix of different renewable types. Micro-wind can make an important contribution to that mix, and Wales has one of the best wind resources in Europe. From this background, an initial study into the main technologies on offer makes great sense.

This study is the result of research carried out on small-scale wind technologies, combined with a trip to the manufacturers of the Swift and Windsave turbines. As part of the RES-e regions project this document covers issues specific to Wales. There is however, a very wide correlation between conditions in Wales and other parts of the UK, and it is hoped that this document will prove useful to a wide range of people from a large geographic area. For further information about the RES-e project, and to download further documents, visit www.res-e-cymru.org.uk

Typical Characteristics

Small roof-mounted turbines are designed for large-scale deployment in many areas; rural, urban and brown-field. Because of the large target locations, they have very specific characteristics which must be met in order to comply with the demands and expectations of consumers, planners and the distribution network operators (DNOs). These include:

- Low noise levels
- Reliable operation
- Value for money
- Minimised visual intrusion
- Compliance with all safety requirements, both structural and electrical

It cannot be emphasised strongly enough that installations which are unsafe or cause problems to properties to which they are attached, or devices which fail to live up to expectations regarding performance, have the potential to severely undermine confidence in this nascent sector.

Caveats

The development of domestic roof-mounted wind turbines has only just begun. The two turbines investigated here are at the post-development stages and are gearing up for mass production. This means that prices for installed turbines are currently far in excess of the target price. Work done on payback times is performed using the **final target price**, which is probably some 18 months away for Swift, and perhaps 12 months away for Windsave.

There is currently no mechanism for getting paid for electricity exported to the grid, or for claiming Renewable Obligation Certificates (ROCs). The control panels of both turbines display indicative values of kWh produced, but this is not sufficient for DNOs to credit electricity payments or claim ROCs. This greatly decreases the cost-effectiveness of the turbines, although it should be pointed out that the environmental benefits of increasing locally generated electricity still exist. To increase the cost-effectiveness of the turbines, a method of energy storage, such as an electric immersion heating element in a water tank, should be used. This will help ensure that all of the production of the wind turbine is matched by the load of the household. This caveat is probably less of an issue for businesses where there is likely to be some level of 24hr loading. Work done on payback times therefore **assumes that the output of the turbine is completely matched by the load**. Where an immersion element is not available, this assumption is stretched and the payback times should be viewed accordingly.

This report is written in the climate of unsettled but increasing energy prices. DTI statistics catalogue a rise in electricity prices by 11.2% from March 2004 to March 2005. To suggest that electricity prices will not rise in the future would be contrary to the projected increase in worldwide demand for gas (the single largest component of the electricity generating fuels in the UK). Indeed, prices for gas have risen even faster than electricity prices over the last year. The calculated payback times therefore **include a 10% annual increase** in the price of electricity charged to consumers. This document is likely to be revisited several times as development of turbine technology continues, and the electricity prices will be reviewed as part of the update.

The payback time of a turbine will be influenced by any grant support available. At the time of writing, Swift was accredited for Clear Skies grant funding of £1500. Windsave was undergoing the accreditation process, and the assumption has been made that the application for accreditation will be successful. **The grant funding has not been included** in calculation of payback times, as the cost of installation has been estimated to be roughly equivalent to the available grant.

The final important point when considering payback times for any wind turbine is the windspeed at its location. There is an online resource available to determine average windspeeds at a given location to the nearest square kilometre (http://www.dti.gov.uk/renewables/technologies/windspeed/online.html). Although this should not be used for detailed study, it suggests that a windspeed of 4.5-6ms^{-1} is typical for an urban site at 10m hub height. There is not much data on whether the siting of a turbine on a roof reduces yield due to turbulence or increases it due to a "wind flow enhancement" process. Given the above, **a windspeed of 5.5ms^{-1} has been selected** as the basis for payback times.

Windsave has yet to produce a power curve for their turbine. Without this information it is impossible to determine payback times. It is hoped that this will become available by Autumn 2005. For this version of the document **Swift is the only turbine for which payback times have been calculated.**

Quick Comparison

The following table offers a quick overview of the two turbines.

	Swift	Windsave
Rated power (W)	1500	1000
Cost (£/W)	1	1
Diameter (m)	2	1.75
Turbine mass (kg)	50	25
Clear skies accredited	Yes	Undergoing accreditation
Headline payback time	8 years	5 years claimed*
Anticipated lifetime	20 years	10 years
Claimed annual yield	4,000kWh	1,125kWh
Estimated annual yield	1,753kWh	N/A
Immersion heater system	Standard	No
Extreme wind level	$65ms^{-1}$	$52.5ms^{-1}$

*No power curve available

Swift

The Swift turbine is manufactured by Renewable Devices, a renewable energy consultancy based approximately 7 miles outside Edinburgh city centre. The company has a staff of 17 (undergoing rapid expansion) and the product has been in development for five years. All the parts for the turbine are sourced within the UK, with the majority from the Mid-Lothian region, although none are from within Wales.

The company has won an award for its business every year since 2002:

- 2002 The Scottish Executive Smart Innovation Award
- 2003 The Scottish Executive Spur Innovation Award
- 2003 Scottish Renewables Forum Green Energy Award - Best New Business
- 2004 Ashden Award for Sustainable Energy - UK Energy Generation Winner

Scottish and Southern Energy has a 20% stake in the company, and will be the contracted installing body for the turbine.

Technical Details

Noise

The Swift wind turbine has an unusual design which effectively eliminates noise from the turbine operation at all windspeeds, negating this as a possible objection under planning applications (noise levels are less than 35dB at all operational speeds).

Water Heating

There are two standard packages, either with or without an electric immersion heater. This enables householders to maximise the energy yield of the turbine with a water heating component, or small businesses to use the entire production as displacement of mains electricity.

Turbine and Electrical Integrity

The turbine exceeds British Standard for forces on the structure. The turbine tower likewise exceeds British Standard. Rotor design and shaft integrity exceed the relevant standards. The rotor and yaw bearings specifications significantly exceed the lifetime of the whole turbine. Electromagnetic and electrical safety specifications are met. These details are all publicly available in the due diligence report performed on behalf of the Energy Savings Trust by Entec UK, an engineering consultancy.

Payback

Calculated using an windspeed of $5.5ms^{-1}$, giving an average output of 200W, for an annual yield of 1,753kWh.

Year	1	2	3	4	5	6	7	8	9
p/kWh	8.00	8.80	9.68	10.65	11.72	12.89	14.18	15.60	17.16
Value/£	140.24	154.26	169.69	186.69	205.45	225.96	248.58	273.47	300.81
Total/£	140.24	294.50	464.19	650.88	856.33	1082.29	1330.87	1604.34	1905.15

For a baseline scenario the payback for the Swift turbine is something less than 8 years. Against an equivalent cash investment at a bank rate of 5% the payback timescale increases to 11 years.

Windsave
Windsave is based close to Glasgow city centre and employs 12 people. Most of the turbine components are sourced within the UK, with some of the electronics coming from Wrexham. Windsave has been nominated for various business awards:

- 2004 VIBES regional award winner (West Scotland)
- 2004 Energy Institute Innovation Award shortlisted
- 2004 Scottish renewables Best New Business Award Nominee

British Gas has an agreement with Windsave to act as the installer for the turbines.

Technical Details

Noise
Published data give the noise levels at 5m behind the blades as 33dB at $5ms^{-1}$, rising to 52dB at $7ms^{-1}$. Planning guidelines suggest a night time maximum of 43dB, and a daytime level of background noise +5dB. Although this is not likely to affect isolated installations in rural areas, there is a potential problem for large-scale deployment within domestic areas.

Water Heating
The default system inputs electricity into the general house electricity circuit. There is currently no system available to heat water directly from the system.

Turbine and Electrical Integrity
No due diligence report currently available. Conforms to British Standard for rotor load and to the relevant legislation for electromagnetic and electrical safety.

Payback
Claimed as five years by Windsave, but presently no power curve available.

Conclusion

At this early stage of development there is a great deal of excitement and potential regarding domestic roof-mounted wind turbine, but until the installed costs start to approach the target prices, the turbines will remain as potential. Both companies have of the order 20-30 wind turbines installed, and there will doubtless be a massive learning curve, with data from the early installations being invaluable for the future roll-out nationwide.

On the basis of the information currently supplied and the current costs, neither product could be recommended in terms of cost-effectiveness. There are clearly alternatives which offer a more attractive investment. This would not be the case were the turbines available at their target price.

It is clear that presently Swift is the more attractive proposition, based on their accreditation with the Clear Skies grant scheme, the wealth of publicly-available information about the physical characteristics and the performance, and the lack of foreseeable problems regarding the noise issue at the planning stage. What remains to be seen is whether that will still be the case as Windsave produces more information over the next 6 months.

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Appendix

Other Small UK Wind Turbines

The main focus of this document is on domestic-scale rooftop systems. There are larger rooftop systems which would be more appropriate for larger buildings such as schools or other public buildings with the capacity to bear the necessary forces on a larger turbine.

The main company involved in this field is Proven Energy of Stewarton, Scotland. They install roof-mounted systems of 600W, 2.5kW and 6kW, and a larger tower-mounted 15kW turbine.

As a guide, the table below indicates typical payback times assuming use of a clear-skies grant (up to 50% for local authorities, community groups etc, smaller for domestic users) and an average windspeed of 5.5ms^{-1}. Costs include tower, VAT and a surcharge of 15% to cover installation. This is an indicative value only. Payback time has been calculated approximately against an equivalent cash investment.

For the 2.5kW and 6kW turbines a ROC payment has been included at 4p/kWh. Full load matching is also assumed, as for larger generators it is more usual to have an export agreement with a DNO.

	Cost (£)	Annual Output (kWh)	Payback time (yrs)
0.6kW (domestic)	2770	1315	23.3
2.5kW (community)	3760	4383	9.5
6.0kW (community)	7320	10520	7.7

A list of UK-based turbine manufacturers and their contact details follows:

Manufacturer	**Turbine Size (kW)**	**Website**	**Telephone**
Iskra	5	www.iskrawind.com	0115 841 3283
Gazelle	20	www.mkw.co.uk	0191 413 0012
Proven	0.6-15	www.provenenergy.co.uk	0156 048 5570
Swift	1.5	www.renewabledevices.com	0131 535 3301
Windsave	1	www.windsave.com	0141 353 6841