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Product Group Study

Drivers and barriers for remanufacturing of small- and medium-scale wind turbines

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Summary

This report investigates life-extension activities for small- and medium-scale (up to 500–600kW) wind turbines in a UK context. Such activities include servicing, repair, refurbishment, remanufacture and reuse. Refurbishment and remanufacture are focused upon in this work.

The small-scale wind industry has been growing in the UK in recent years, and the introduction of Feed-in Tariffs (which will provide the owners of small generators with guaranteed income) is likely to cause yet further growth. Servicing and repair operations are common, but the refurbishment and remanufacture of end-of-life small-wind turbines (≤50kW) have thus far been rare. This is because the installed base of turbines is still small and hence there are currently few second-hand units available, but also because of economic and, perhaps, technical barriers.

The production of new medium-scale turbines has been in decline because major manufacturers have shifted operations to larger turbines. However, the refurbishment and remanufacture of medium-scale wind turbines has been popular, particularly in other parts of Europe and the USA but also in the UK. These activities have been enabled by the availability of second-hand turbines, the technical amenability of the turbines for remanufacture, and by attractive economic performance.

A key driver of demand for remanufactured medium-scale wind turbines is their low capital costs compared to new equipment. Case studies in this report indicate that reductions of the order of 50% are possible. Such upfront cost reductions are of particular significance given that the recent 2010 Budget has warned of emerging equity gaps for low-carbon infrastructure development.

Other benefits of remanufacturing wind turbines are the material, energy or carbon savings that are possible compared to new-turbine production. Research cited here suggests energy savings, for example, can be in the region of 80%. Further research is recommended to investigate resource-savings and other environmental benefits in more detail, and to compare remanufacturing with other end-of-life options such as recycling.

Despite the possibility of economic and environmental benefits, the wind-turbine remanufacturing industry appears to be in decline in the UK. Major reasons for this appear to be the uncertainty and direct barriers introduced by recent Government policy, particularly where the new Feed-in Tariffs exclude refurbished or remanufactured turbines. This report recommends that Government considers accepting such turbines to thus encourage development of the remanufacturing industry. In this context policy-makers and others have indicated a general need for clear definition of what is meant by ‘refurbished’ and ‘remanufactured’. For this, the recently-published British Standards dealing with remanufacturing will be useful and are referenced by this report.

1 Remanufacturing of small- and medium-scale wind turbines

1.1 Research methodology

This report investigates historical and potential life-extension activities for small- and medium-scale wind turbines (rated capacities of up to approximately 500–600kW) in a UK context. Such activities include servicing, repair, refurbishment, remanufacture and reuse; refurbishment and remanufacture are the focus of this work.

The research involved a review of literature and interviews with organisations associated with any combination of the manufacturing, sales, maintenance, refurbishment and remanufacturing of wind turbines. Sources included more than ten industrial companies; the wind-industry representative RenewableUK (formerly the British Wind Energy Association; BWEA); the UK Government's Department for Energy and Climate Change; and the regulator, the Office of Gas and Electricity Markets (OFGEM).

1.2 Life-extension activities in the wind industry

Small-wind industry

The small-wind industry has a world-leading manufacturing base in the UK, and by 2008 over fifteen UK manufacturers were producing micro- and small-wind systems in the 0.1–50kW range [2]. During 2005–08 some 10,000 units were installed in the UK while a further 10,000 were exported [2], reflecting a take off in the output of the manufacturing sector. With April 2010's introduction of Feed-In Tariffs (FITs) – financial incentives to encourage the adoption of small-scale, low-carbon electricity generation – there could be an explosion in activity and output of the industry over coming years.

To maximise operational life, servicing and (if necessary) repair activities are common for small wind turbines, just as for larger turbines. Warranty periods usually extend to 1–5 years and cover parts and sometimes labour costs, and, for turbines they have sold, manufacturers or distributors typically provide warranty-based maintenance or repair services. Outside of warranties, these same groups often continue to offer such services on a chargeable basis, and there also exist companies from various backgrounds that offer service contracts whether or not they sold the turbine in question.

While maintenance and repair activities are commonplace, there appears to be a general lack of the more significant life-extension activities of refurbishment and remanufacturing in the small-wind industry – only isolated cases were found during this research. Two particularly prominent reasons for this were apparent. First, while the industry is growing, the installed UK base of turbines is still relatively small, and there is a current lack of second-hand turbines available for refurbishment or remanufacture. Second, a number of companies with experience of refurbishing or remanufacturing wind turbines did not consider it financially viable at the small (sub-50kW) scale. They considered the cost of refurbishment or remanufacture too high relative to the revenues (via sales) they could subsequently generate.

Medium-wind industry

In contrast to the recent growth of the small-wind industry, manufacturing of medium-scale turbines has reduced significantly. This is due to a trend, in the larger-scale wind industry, toward bigger turbines [1] that typically entail larger profit margins. As the (global) industry developed through the 1980s and into the 1990s, leading manufacturers increased the size of their turbines from sub-100kW machines into the hundreds-of-kilowatts range, before continuing into the multi-megawatt turbines that currently proliferate in the 'new turbine' marketplace. Throughout this process manufacturers have usually abandoned production of the earlier, smaller designs.

Repowering[1] activities, particularly in countries such as Denmark, Germany and the USA, have created an active second-hand market for wind turbines, the rated capacity of which is reflected by the typical installed capacity 'one lifetime ago' [1]. In recent years these have been the medium-size (hundreds-of-kilowatt) turbines of the late 1980s and 1990s. The refurbishment and remanufacture of such turbines has been particularly popular in areas of close proximity to second-hand markets such as the USA, Denmark, the Netherlands, and Germany [1]. Walton and Parker [1] estimated that the market for second-hand turbines could remain significant into the future, with up to 2,000 units per year becoming available by 2024. The prominent size of these turbines will increase in accordance with the dominant 'one-lifetime-ago' capacity at any given time.

The refurbishment and remanufacturing of wind turbines has been less prevalent in the UK, but nevertheless a number of UK companies were advertising involvement with refurbished or remanufactured turbines at the time of this research. These include EWind [3], Stone Wind & Solar Co. [4], Green Dimension [5], Segen [6], and ZF Great Britain [7]. Others, such as Rotary Engineering [8] and BMP [9], were also advertising maintenance, manufacturing or remanufacturing operations related to the wind industry. In addition, Walton and Parker [1] have indicated that while the UK does not have a well-developed indigenous (larger) wind-turbine manufacturing industry, it is endowed with the appropriate allied engineering and logistical skills that might be directed to remanufacturing. In the right environment, it appears that wind-turbine remanufacturing could flourish in the UK.

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[1] 'Repowering' refers to the replacement of one wind turbine by a newer and typically larger model.

However, during this research it appeared that the UK wind-turbine remanufacturing industry is in decline. The most prominent reason given for this by remanufacturers was the introduction of FITs, for which refurbished or remanufactured turbines are ineligible. Companies are thus reducing or abandoning operations with, and sales of, such turbines in the UK. FITs are discussed in Section 3.2. The following two case studies give examples of both historically successful installations and the current situation for individuals or organisations interested in purchasing and installing refurbished turbines.

1.3 Case studies

Sources of demand for medium-scale wind turbines include the range of enterprises and community-based organisations looking to reduce their carbon footprint via renewable energy projects. Walton and Parker [1] noted that the price and (large) size of the latest new units have made their application untenable for these markets, whereas the typically cheaper, second-hand medium-scale units have presented a viable option. The current lack of availability of new medium-scale turbines (due to reduced manufacturing operations) is a further barrier to the use of new turbines, and a driver for the use of refurbished or remanufactured turbines.

Bro Dyfi Community Renewables

The community energy co-operative ‘Bro Dyfi Community Renewables’ (BDCR) have installed and used two refurbished wind turbines since 2001. The first was a 75kW Vestas ‘V17’ machine, installed in 2001 on a 20m tower. BDCR bought the turbine, which was manufactured in 1985, from a small wind farm in Denmark that was undergoing repowering. The total project costs (purchasing, installation and grid connection) were £85,000, of which £15,000 was for the turbine and its shipping costs from Denmark. £36,500 of the total was raised over a 2–3 year period via a share offer, and the remainder was funded by a European grant.

BDCR have sought to maximise the return on their investment. Although they found the process for selling electricity complicated (an often-quoted historical barrier to smaller renewable electricity schemes), they have been doing so successfully since 2003, most recently to the energy company Good Energy. They have received important additional revenues via the Renewables Obligation and the Climate Change Levy. Annual earnings have been £10,000–14,000 and the project broke even during 2007, roughly four years after electricity-sales began. Interestingly, having successfully made their case BDCR appear to have been the first refurbished turbine to be accepted into the RO and Climate Change Levy schemes. (OFGEM, who administer the RO, have reached such decisions historically on a case-by-case basis, since clear definitions from Government for what can be accepted as refurbished or remanufactured seem to have been lacking. This is discussed in Section 3.2.)

The second refurbished wind turbine that BDCR installed was a (Danish) Nordtank 500kW machine, installed in 2008 on a 32m tower. In this case BDCR were able to buy a site from the local ‘Centre for Alternative Technology’, who has used the site to develop a prototype wind turbine and thus already had a grid connection. The turbine came from Germany, again from a wind farm that was repowering. The turbine had a (relatively commonplace) gearbox problem and this was the major area requiring refurbishment. Compact Orbital Gears, a local company from Rhaydaer, mid-Wales, carried out a complete refurbishment of the gearbox and provided a year's warranty.

The 500kW installation had a total project cost of £300,000. Of this, approximately £190,000 was raised through a share offer, £60,000 was won from European grant funding sources, and £50,000 was received as a loan from Finance Wales, part of the National Assembly. The cost savings made through using a refurbished rather than new turbine were considerable: new-turbine options at the time were £500,000, not including the required foundation or grid connection.

BDCR have been pleased with the performance and reliability of both refurbished turbines. The wind industry typically measures reliability in terms of 'availability' – the proportion of year that the turbine is available (whether it is ready to generate or actually generating). The 75kW turbine, for example, has exhibited availability well above 90%, which BDCR indicated is comparable with new wind turbines. These figures are particularly good considering that BDCR is a voluntarily-run organisation and thus, in the absence of the dedicated maintenance support groups used by most industrial wind farms, lead times to any repair or maintenance activities are often increased.

Ouse Valley Energy Services Company

The Ouse Valley Energy Services Company (OVESCo) is an Industrial and Provident Society set up in 2007. In addition to providing advice to the community to reduce the use of non-renewable energy, and administering renewable energy grants on behalf of Lewes District Council, OVESCo are looking to develop renewable-energy projects in the area, funded at least partly by selling shares locally.

Two potential sites have been identified for turbines in the 200kW range. The best of these is particularly suitable, close to the top of a coastal hill with average wind speeds of 7.5 m/s, and situated by a sewerage works and a high power substation, away from houses. OVESCo hope to partner the landowner and lease the land in return for a share of the generation proceeds.

When OVESCo began considering the scheme they found a British company offering refurbished Vestas 'V25' 200kW wind turbines, sourced from Denmark, for approximately £200,000 installed (£1000 per kW). Unfortunately, in response to the introduction of FITs and the ineligibility of refurbished turbines, the company is changing their business model and moving away from refurbishment, an area in which they had established skills. Instead, they can now offer OVESCo a new Wind Energy Solutions 'WES30' 250kW turbine for approximately £450,000 (£1,800 per kW) – an almost doubling in price.

The higher upfront costs of the project are making the finances much more marginal for OVESCo, and its future is currently uncertain.

2 Drivers for remanufacturing

2.1 Introduction

Successful remanufacturing activities can have all-round sustainability benefits, including in terms of economic productivity, the creation of skilled jobs, and by enabling savings of material, energy and carbon emissions. A recent report, for example, found that remanufacturing in the UK contributes around £5 billion to GNP, employs 50,000 people, and recovers some 270,000 tonnes of material with an associated saving of 800,000 tonnes of CO_{2eq} [10].

However, the drivers underlying particular remanufacturing activities vary across different industrial sectors and hence case-by-case investigations are useful. In the wind industry, for example, both the discussion here and within a previous, related report [1] have noted that repowering activities in the USA and across Europe have been a key historical enabler of refurbishment and remanufacturing activities through the provision of second-hand units; details that are specific to the wind industry.

2.2 Economic benefits

Examples given here (in Section 1.3) and by Walton and Parker [1] indicate that significant capital cost savings are possible via refurbished or remanufactured wind turbines, and that this can be a key enabling factor for wind-turbine installations within emerging markets such as community groups, local governments, and businesses. This is particularly important in light of the 2010 Budget and accompanying 'Energy Market Assessment', which indicated that the financing of a low-carbon system will require unprecedented levels of capital expenditure and that, crucially, there are emerging equity gaps for low-carbon infrastructure development [11;12].

2.3 Environmental benefits

Although many remanufacturing activities have been driven by economics, they also typically entail environmental benefits [10]. These benefits are derived from the reduction of waste flows and the associated increase in resource-efficiency that is enabled by the remanufacturing and reuse of end-of-life products. Material, energy and carbon savings are particularly important given the challenging targets set by the 2008 Climate Change Act to cut UK carbon emissions by 34% by 2020 and at least 80% by 2050 against the 1990 baseline level.

To provide an assessment of the resource savings made possible by wind-turbine remanufacturing, various environmental life-cycle assessments (LCAs) of wind-turbine production and use were reviewed from available literature. Environmental LCAs aim to quantify environmental impacts of products or systems over their whole life cycles, from 'cradle to grave' [13]. LCAs also aim to include not only direct impacts, such as electricity or fuel use during manufacturing, but also indirect impacts, such as the 'upstream' energy requirements of extraction and pre-processing of raw materials. Of the LCA and related literature reviewed during this research, energy-resource requirements were the most popular and consistently reported environmental-impact category, and hence the present discussion focuses in this area.

Table 1 summarises the energy requirements of some small- and medium-scale wind turbines, mostly of an age appropriate for current remanufacturing activities. The 'embodied energy' values include manufacturing and, in some cases, the operational and maintenance life-cycle stages, but do not include end-of-life energy requirements such as disposal. This is because these requirements were excluded in many of the studies. (Remanufacture and reuse, as one option that exists instead of disposal, is discussed below.) The 'energy payback period' is based on the assumption that the turbines are displacing conventional and established generation plant, such as fossil-fuelled power stations. It is defined as the time taken for the wind turbine to displace a quantity of (primary) energy resource equal to its embodied energy.

Table 1: Life-cycle energy indicators for small- and medium-scale wind turbines

Reference	Year of study	Rated power (kW)	Embodied energy (GJ)	Energy payback period (years)	Notes
[14]	2008	0.6	5.32	1	Average payback for a sample of rural environments. Assumes mounting on a metal scaffold pole.
[15]	1995	15	233	0.8	Vintage turbines from 1980. Assumes metal towers and 'relatively poor siting of roughness class 2.'
[15]	1995	22	340	0.9	
[15]	1995	30	358	0.9	
[15]	1995	55	474	0.5	
[16] in [17]	1991	95	835	0.5	Metal towers. Paybacks have been estimated here on the assumption that wind turbines displace conventional plant with conversion efficiencies of 35%, in accordance with [17].
[18] in [17]	1990	150	748	0.2	
[16] in [17]	1991	150	1187	0.3	
[19] in [17]	1991	300	2793	0.3	
[15]	1995	600	3170	0.3	Metal tower; roughness class 1-2.

When comparing the results of different studies there are issues including differences in the estimation methodologies (including analysis scope and breadth), hub height, assumed or actual wind resource, and the country of manufacture. Nevertheless, Table 1 suggests that economies of scale exist regarding the energy payback period – i.e. that larger turbines generally exhibit better life-cycle energy performance than smaller turbines. This was a finding of Lenzen and Munksgaard

[17], who reviewed 72 LCA or similar studies of wind turbines ranging from sub-kilowatt to multi-megawatt machines. (The illustrative results referred from that study in Table 1 were selected on the basis of sizes relevant to the present discussion.) However, economies of scale are only one factor for consideration, particularly since energy payback periods are much shorter in all cases than expected turbine lifetimes of approximately 20 years. Table 1 thus indicates that all turbines provide significant net energy savings during their service lifetime.

The remanufacturing and reuse of turbines after their first service life has the potential to provide further energy-resource savings, depending on the energy requirements of remanufacturing. There is currently a paucity of literature involving such energy requirements, but Pernkopf [16] (in [17]) found that, for a 30kW wind turbine, a complete overhaul and reinstallation at the end of the first service life, involving the exchange of rotor blades, pitch control, hub, bearings, cogs, hydraulics and cables, requires only about 20% of the original total energy requirement.

It is likely that such large savings are possible because components with significant initial energy requirements do not need much if any refurbishment, such as the tower. When analysing eleven studies, Lenzen and Munskgaard [17] found that the tower represented more than 40% of the total energy requirement. The significance of the tower is a finding that agrees with those of other studies, such as Krohn [15], Allen et al. [14], and Crawford [20].

While further research is desirable to corroborate or contradict the figures quoted above, it appears that energy requirements for remanufacturing are significantly smaller than for the original manufacturing process. Energy payback during the second service life would therefore be even shorter that those shown in Table 1, and remanufacturing would be justified and desirable in net energy terms.

Further research is recommended in the following areas:

- To broaden the scope to consider other environmental impacts and resource issues, such as greenhouse gas emissions and the availability and price of raw materials. (Shortages of materials or price increases might strengthen the case for remanufacturing through reuse of material resources.)

- To compare remanufacturing and other end-of-life options such as recycling.

3 Barriers for remanufacturing

3.1 Introduction

The UK Government has long recognised the need for increased resource efficiency and decreased waste in order to enable sustainable development (e.g. [21]), and remanufacturing can often contribute to these aims [10]. But although the practice of remanufacturing now attracts government support (in the form of subsidies) in the USA to promote its benefits for sustainable development, the industry has a low-profile in policy-terms in the UK and appears to be generally in decline [10].

Indeed, this research found that increasing policy-related barriers are causing a decline in UK remanufacturing activities for wind turbines. The major reason for this given by industrial interviewees was the introduction of policy and regulatory changes by the UK Government that are providing uncertainty and even significant barriers for refurbishment and remanufacturing activities. On the other hand, Government-department representatives indicated interest in supporting refurbishment where appropriate, but also challenges for achieving this in the current policy landscape. This section provides an overview of these issues in particular, along with other barriers identified during this research.

3.2 Policy and regulatory issues

Background

The 2008 Climate Change Act set legally binding ‘carbon budgets’ for the UK, and aims to cut UK emissions by 34% by 2020 and at least 80% by 2050 against the 1990 baseline level. In this context the UK Government aims to provide around 30% of electricity from renewable generation by 2020, up significantly from about 5.5% in 2009 [22].

To meet the challenging targets set by the Climate Change Act, the Government is using a variety of existing and new policy mechanisms to encourage significant deployment of renewable-electricity generators, two of which were found to be of key significance in the context of remanufacturing. At the larger and generally industrial scale, the revised ‘Renewables Obligation’ (RO) is the main policy mechanism [23], while at the smaller-scale the introduction of ‘Feed-in Tariffs’ (FITs) aims to encourage the wider public (householders, communities and businesses) to adopt renewable generation [24].

These two policies are providing uncertainty or even direct barriers for the UK's wind-turbine remanufacturing industry. While remanufactured turbines have been eligible for the RO (as illustrated by the BDCR case study in Section 1.3), there is uncertainty about such eligibility while the definition of such turbines is determined by Government [23]. At the same time, remanufactured turbines are to be, at least initially, ineligible for FITs that begin in April 2010 [24]. This has significant ramifications for wind-turbine remanufacturing in the UK, and was given by a number of industrial interviewees as the major reason they are reducing or ceasing UK-focused remanufacturing operations while turning to other business models.

During interviews with relevant Government departments, some of the policy-issues concerning refurbished or remanufactured wind turbines were found to be general to both the RO and FITs, while others were specific to each. Accordingly, the following section discusses general issues, before subsequent sections discuss issues specific to each individual policy.

General issues for remanufactured wind turbines

There are three general and related issues that impinge upon policy-support for remanufactured wind turbines: EU State Aid rules; the risks of 'gaming' through a rotation of assets; and the need for definition of 'refurbishment' or 'remanufacture' of wind turbines.

EU State Aid rules aim to ensure fair and effective competition and a single common market [25;26]. State Aid measures are allowable when they are deemed to be in the common interest of the European Union, such as for the protection of the environment [25]. The UK must comply with State Aid rules when designing and implementing policies such as the RO or FITs. An interviewee from the Government's Department of Energy and Climate Change (DECC) highlighted that any policy that supports the refurbishment or remanufacture of wind turbines has to be careful not to be deemed to be 'overcompensating' renewable generators by providing funding to generator during a second service life.

A related issue is the risk of the owners of generators 'gaming' the system and receiving unjustifiable funding, perhaps by refurbishing generators simply to access funds.

In both of these cases, there is a need for a clear and robust definition of what is acceptable, for funding purposes, as a 'refurbished' or 'remanufactured' wind turbine. In this context, a DECC interviewee expressed interest in the recently developed British Standards regarding remanufacturing and its definitions [27-29], and to receive input from stakeholders in this area.

Renewables Obligation

The Renewables Obligation supports larger-scale renewable-electricity generation by issuing 'Renewable Obligation Certificates' (ROCs) to generators for a defined amount of renewable electricity. Generators can then sell these certificates in a market (to electricity suppliers) and earn revenue in addition to the market-price for electricity.

Refurbished or remanufactured wind turbines have been able to access the Renewables Obligation in recent years, as highlighted by the BDCR case study in Section 1.3. However, applicants have been assessed on a case-by-case basis by OFGEM, the regulatory body that administers the RO, and hence eligibility has been unclear for potential applicants. (Applicants apply to OFGEM via the 'Renewables and CHP Register', through which they can also receive accreditation for the Climate Change Levy. The current legislation followed by OFGEM during assessment of a generator is the Renewables Obligation Order 2009, of which Articles 18(1) and 18(3b) are particularly relevant.)

When the UK Government recently consulted on financial incentives for renewable electricity, they found almost unanimous support for the inclusion of refurbished plant in the RO [23]. At the same time, respondents stressed the need for clear definition of such plant, and during this research a DECC interviewee indicated that Government intends to consult on this during summer 2010.

Feed-in Tariffs

Feed-in tariffs are a new financial-support scheme (coming into force in April 2010) to encourage the adoption of renewable-electricity generation of up to 5MW rated capacity. FITs will guarantee payments to generators from licensed electricity suppliers and thus provide a more secure (but potentially less lucrative) return on investment than the RO. FITs have been designed to complement the RO and are aimed particularly at householders, organisations, businesses and communities that have not traditionally engaged in the electricity market in mind. The FIT scheme thus aims to be simpler to understand and navigate than the RO.

Unfortunately for remanufacturers, the FIT scheme will not, at least initially, accept refurbished or remanufactured generators. There are two main issues underlying this position: the cost analysis that underlies the tariff design; and DECC's position regarding existing generators. A further issue for any remanufacturer considering wind turbines of less than 50kW is the Microgeneration Certification Scheme.

DECC's main stated objective of the FITs scheme (in its current form) is to encourage new entrants into renewable and low carbon electricity generation [24], and the tariff levels have thus been designed on the basis of cost assumptions for new technologies (given by [30]). Refurbished or remanufactured turbines are therefore currently ineligible for FITs because they have a different cost base to new technology. DECC are, however, keeping the issue under review [24], and a DECC interviewee indicated that options do exist for supporting refurbished turbines, such as alternative tariffs or shorter tariff lifetimes. (Part of the reason for keeping these issues out of the initial FIT scheme was the desire to avoid over-complication at the introductory stage.)

For existing or potential remanufactured turbines of under 50kW, another problematic issue is DECC's stance on existing microgenerator (≤50kW) installations. From 1 April 2010 microgenerators that are eligible for FITs (AD, hydro, solar PV and wind) will no longer be eligible for the RO[2]. Micro-generators installed before 15 July 2009, the publication date of the Renewable Energy Strategy and the Consultation on Renewable Electricity Financial Incentives 2009, will be ineligible for FITs unless they had applied for the RO before 15 July 2009. In the latter case they can receive the 'RO transfer tariff', but this is a reduced tariff compared to that for new installations. This approach has been controversial because it has been seen by some to penalise 'early adopters' of microgeneration technologies (e.g. [31]), but DECC 'continue to believe that allowing all existing installations access to FITs would not only increase the overall costs of the scheme but would not encourage additional generation' [24].

The significance of DECC's stance is that they are now wary of accepting refurbished microgeneration plant because people may be incentivised to unnecessarily 'refurbish' existing installations in order to access FITs. This problem highlights both difficulties with DECCs current stance (from the perspective of refurbishment) and the recurring need for a definition of what would be accepted as a 'refurbished' or 'remanufactured'.

An extra issue in the microgeneration (≤50kW) area is the Microgeneration Certification Scheme. For new micro-generation installations, technologies will have to be certified under the Microgeneration Certification Scheme (MCS), and to be installed by MCS-accredited installers[3]. Certification under the MCS is designed to give greater protection and confidence to consumers considering microgeneration. But even if the MCS were altered to accept refurbished or remanufactured turbines, the upfront costs of certification are high (various interviewees indicated these to be in the region of £80,000 per microgenerator model). This creates a further barrier to entry for a potential sub-50kW remanufacturer.

[2] Installations with a capacity greater than 50kW, or installations of any capacity in technologies not covered by FITs, will still be eligible to apply for support through the RO.

[3] This does not apply to micro-generators that have previously gained accreditation under the RO, if they are transferring to the FIT scheme.

3.3 Further issues

A few further existing or potential barriers to wind-turbine remanufacturing were identified during this research, including the currently small number of wind turbine installations in the UK; economic and technical barriers for small-scale turbine remanufacturing; and the varying perceptions held of remanufacturing.

In both the small and medium-scale wind industry, the current installed base of turbines in the UK is small, and this creates a barrier to remanufacturing through the lack of available second-hand units ('core'). This small base is, however, expanding thanks to recent and expected growth in the industry (BWEA have suggested that total installed numbers could be 600,000 by 2020 [2]), and the number of medium-scale turbines may also grow in response to the introduction of FITs. Further research could look into these issues in more depth to provide an up-to-date projection of the availability of 'core' turbines for remanufacturing in the future.

In the case of small wind turbines of less than 50kW in rated capacity, this research has indicated that remanufacturing activities have not been financially attractive. Ineligibility for the MCS and FITs provide further discouragement to potential remanufacturers at this scale. One or two remanufacturers also thought that technical barriers may exist for successful remanufacturing. Many small turbines, for example, are direct-drive systems, and thus do not employ the gearboxes that are popular for remanufacturing operations. Further research is recommended to investigate these issues.

Finally, perceptions of remanufacturing were found to vary significantly among interviewees. Some remanufacturers and users of remanufactured machines asserted that such machines are of a high quality and reliability, pointing out that, particularly in the case of medium-scale turbines, the technology and designs have been well-proven throughout the 1980s and 1990s. Other interviewees, however, expressed concern about the longevity and reliability of remanufactured units, saying that old designs have been superseded by better and more reliable models. Further research would be beneficial to investigate these contradicting viewpoints.

4 Recommendations

Remanufacturing is pertinent to sustainable development for a variety of reasons [10] including savings of materials, energy, and greenhouse gas emissions. This is not, however, generally recognised in the UK at a policy level, and traditional remanufacturing activities have been driven largely by economics alone.

The capital cost reductions enabled via the remanufacture of wind turbines have been a key driver of demand from, for example, organisations wishing to reduce their carbon footprint with affordable renewable-energy projects. Reductions of approximately 50% have been described in the case studies of this report. Such upfront cost reductions are of particular significance in light of the 2010 Budget [11] and related 'Energy Market Assessment' [12], which together indicated that the financing of a low-carbon economy will require unprecedented levels of capital expenditure and that, crucially, there are emerging equity gaps for low-carbon infrastructure development.

The remanufacture of wind turbines can also have environmental benefits in terms of reduced resource requirements compared to new turbines. Research cited in this report indicates that energy savings, for example, were of the order of 80% for the remanufacture of a 30kW turbine. This is likely to be because some components, such as the tower, have significant manufacturing energy requirements but need little or no remanufacturing. Further research is recommended to investigate energy savings in more depth, to broaden the research-scope to consider other environmental and resource-saving benefits, and to compare remanufacturing with other end-of-life options such as recycling.

Despite the possibility of economic and environmental benefits, the wind-turbine remanufacturing industry appears to be in decline in the UK, even though an active industry has been in recent existence and the relevant engineering and logistical skills are abundant. This research indicates that Government policy, in the shape of the Renewables Obligation and the new Feed-in Tariffs (FITs), are providing uncertainty or even direct barriers to remanufacturing. FITs were cited in particular as the reason that a number of companies were reducing or ceasing remanufacturing activities for UK markets.

UK Government departments have indicated that they will be consulting about or reviewing the issue of refurbished and remanufactured wind turbines, in terms of the definitions of such plant and their eligibility for the RO and FITs. It is recommended that remanufactured turbines are made eligible for their capital-cost savings and apparent environmental benefits, and that the new BS Standards regarding remanufacturing definitions are considered to resolve definitional problems. It is also recommended that stakeholders engage Government and contribute to any consultation processes.

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