

## Review of Risk Management arrangements covering provision of Wind Turbines within Highland Council property establishments



*Wind turbine at Craighill Primary School, Tain*

***Prepared by Stuart Duncan, Property Risk Management Officer***

***29 November 2011***

This review considers the risk management arrangements in place relating to the provision of small wind turbines within property establishments owned by the Highland Council.

Note: Small wind turbines are defined in the Classification of Wind Turbines table below;

<b>Small wind turbines</b>	<b>Large wind turbine</b>
Small turbines are defined as having rotor swept areas less than 200 m <sup>2</sup> . produce less than 100 kW of power	Large wind turbine swept area is greater than 200 m <sup>2</sup> , and produces greater than 100 kW of power
Small-scale turbines are typically less than 40 m tall, have rotor diameters less than 8 m, have rotational speeds between 50 and 500 rpm, and weigh between a few kg and 20 tonnes.	Typical large turbine is about 80 m in height, with a rotor diameter of 90 m (swept area of 6360 m <sup>2</sup> ), a nominal rotational speed of 14.5 rpm, and a weight of 250 tonnes.

Note: A further classification of small wind turbines can be made – ‘**Micro**’ wind turbines generate less than 50kw of power and this category best fits the types of wind turbines installed in Highland Council establishments (i.e. 5 – 6kw power installations).

## 1. Introduction

Concern has been raised by a member of the public about the risks of locating wind turbines in schools in areas where people pass below or take part in sports.

A review of available guidance, risk assessments and whether there have been any incidents either in Highland or elsewhere has been carried out to reflect on the adequacy of current arrangements / practice and to consider further improvements if necessary.

**Section 2** of this report provides a profile of incident types;

- a) A selection of press reported wind turbine incidents and profile of the main failure types that have occurred
- b) A summary of an incident that occurred in a Highland Council school
- c) Steps taken by the renewables industry to gather incident information
- d) Enforcement taken by the Health and Safety Executive.

**Section 3** considers available information to inform risk management of the installation of small scale wind turbines e.g. the steps that should be taken to identify and mitigate risks associated with installing and using wind turbines;

- a) Considering 'Objective' risk - the main controls to manage physical and technical risks associated with provision of wind turbines
- b) Risk 'Perception' - expectation and understanding
- c) HSE project to study and develop a methodology for the estimation of the risk of harm to persons in the vicinity of wind turbines.

With the above information in mind, **Section 4** concludes with the outcome of a review of current arrangements used by Housing and Property Services covering provision of Wind Turbines within Highland Council property establishments;

- a) **Policy and risk information**
  - Emerging constraints
  - Existing information
  - Safety and other matters including provision for auditing and monitoring
- b) **Decision making**
  - Site / location
  - Option appraisal
  - Recording decision making - why a preferred location is chosen
- c) **Safety information**
  - Safety statement (site specific)
  - Potential failure covering all site specific aspects
  - Risk mitigation including site rules
- d) **Maintenance**
  - Regimes
  - Funding provisions
  - Routine visual checks (e.g. role of RPO, site staff and area MO)
- e) **Communication**
  - Informing and involving stakeholders.

## 2. Incidents

Information on failure incidents for micro and small scale wind turbines is relatively scarce compared to reports for larger installations however when a failure occurs they are given a high profile in the press.

### a) Press reports

Recorded failure incidents types involving wind turbines reported by the BBC include;

- Fire within the turbine casing,
- Displacement of frozen snow shards from turbine blades,
- Collapse (during erection or use in extreme weather conditions),
- Falling objects (blade parts/springs), and
- Issues relating to maintenance e.g. falls from height, prevention of exposure to live electrical parts.

Wind turbines are mechanical devices exposed to the elements and as such can be subject to failure. Whilst no harm events resulted from these specific incidents there was public concern and questions were asked regarding the steps taken to ensure safety.



Wind turbine at Raasay Primary School

In respect of knowledge of incidents involving wind turbines within Highland Council the failure of the wind turbine at **Raasay Primary School** in November 2009 (where no harm occurred) related to a tension spring which became detached due to inadequate assembly by the installing contractor.

### b) Raasay Primary School

Details including a copy of the incident report into the failure can be accessed at;

[\\ntpahq1\documentmanagement\Risk Management\Library\Reports\Assignments\Wind turbine failure\wind\\_turbine\\_failure.htm](\\ntpahq1\documentmanagement\Risk Management\Library\Reports\Assignments\Wind turbine failure\wind_turbine_failure.htm)

A meeting with Health and Safety Executive (HSE) and Highland Council representatives was held on 22 January 2010 to review the circumstances of the failure at Raasay and to consider the way forward.

The following actions were promoted;

- Corporate policy on the provision and use of wind turbines is to be prepared in conjunction with ECS
- HSE are looking into the incident formally to respond to a public complaint
- HSE are researching information to assemble national guidance on wind turbines particularly for small to medium scale installations and are happy to be consulted (*see report section 3*)
- The Building Research Establishment Ltd (BRE) and Scottish and Southern Energy are to be contacted regarding maintenance and quality assurance procedures.

### c) Steps taken by the renewables industry to gather incident information

[Renewable UK](#) (formerly the British Wind Energy Association, BWEA) is the trade and professional body for the UK wind and marine renewables industries. They have established a [Lessons Learned Database](#) where results of [Small wind incident notices](#) are compiled.

As the Council are not members and information recorded is subject to confidentiality, details of the database were not readily available.

On contacting Chris Streatfield of Renewable UK to discuss how the scheme operates he advised that *'a few incidents have been reported - No public safety incident of concern'*.

Note: Incident data has also been compiled by other manufacturers, operators, research organisations and trade associations though similar restrictions on access to this information are made due to the nature of the failures, public concerns and manufacturers' business concerns.

HSE do not currently have a database of wind turbine failures though they do record enforcement.

### d) Enforcement taken by the Health and Safety Executive (HSE).

The [HSE Public Register of Enforcement Notices](#) contains entries where companies have received enforcement due to wind turbine related incidents.

Searching and filtering for wind turbine related enforcement is not easy due to limited search criteria on the register and a comprehensive list has not been able to be provided.

Note: The entries found below relate to large wind turbine installations;

#### Notice 303365798 served against [East Midlands International Airport Ltd](#) on 28/06/2011

**Notice Type** Improvement Notice

**Description** IN 303365798 served as persons working on control panel in base of wind turbines liable to be exposed to danger as no system to prevent exposure to live parts when panel is opened. IN 303365849 served to adequately consider the risks created by maintenance works on the turbines undertaken by contractors.

#### Notice 300738035 served against [Falck Renewables Ltd](#) on 23/05/2007

**Notice Type** Immediate Prohibition Notice

**Description** Fatal accident at Earlsburn Wind Farm PN issued on 23 May 2007 to prevent access up the wind turbines following failure of the fall arrest system resulting in a fatal accident. No safe system of work for access above the base of the turbines.

#### Details for Case No. 4071126

**Defendant** [Talisman Energy \(UK\) Limited](#)

**Description** Talisman Energy (UK) Limited Beatrice wind turbine prosecution case Failure to adequately plan and risk assess the lifting operation to install a Transition Insertion module resulting in crushing accident

**Offence Date** 25/08/2006

**Total Fine** £225,000.00

**Total Costs Awarded to HSE**

£0.00

### 3. Risk management - Installation of small scale wind turbines

Arrangements for considering risks from installation and use of wind turbines are documented and included as an integral part of formal processes;

Risk aspect	Formal process
Location of wind turbine	<b>Planning application</b> submission; - consultation with stakeholders - consideration of environment, neighbourhood and amenity
Design of wind turbine	<b>Building Warrant</b> application submission; - compliance with building standards and technical regulations - energy and sustainability criteria
Installation of wind turbine Maintenance/Use of wind turbines	Construction (Design and Management) Regulations; - <b>Design risk management</b> covering hazard identification/risk reduction - Review by CDM Co-ordinator of <b>Construction Phase Plans</b> containing method statements for installation works - <b>Health and Safety Files</b> with safety information - <b>Building Manual</b> for operation and maintenance considerations.

Whilst risk management is fully considered within this formal process there are distinct specialties and competencies associated with each aspect. For example;

- The planning process involves considerable interaction with stakeholders on the impact a wind turbine would have on environment, neighbourhood and amenity. The ability to convey technical information in an understandable, practical way to lay persons is a key skill of the **Engineer** leading the team
- Buy-in and co-operation from managers and occupants of the property where the wind turbine is to be located and operated involves good understanding of any factors likely to affect their safety or continuance of service delivery. The **Responsible Premises Officer** (RPO) e.g. Head Teacher in a school property, has a significant role to play
- Design and installation of the most suitable wind turbine for the location involves careful selection and close involvement of; the manufacturer/supplier, **Installing contractor**, and especially co-ordination by the **CDM Co-ordinator** to ensure risks associated with design and construction are fully considered
- **Maintenance, cleaning and servicing contractors** are the final group who have input to contribute their special skills to ensure wind turbines operate safely and as intended. Replacement of wind turbine equipment requirements also need to be appreciated by area Maintenance Officers and involvement of premises staff.

The management of risk transfers like a batten in a relay race from the start – where feasibility studies highlight possible sites through to final switch on where energy and carbon reduction benefits are realised. Risks associated with provision of wind turbines are considered by designers at each stage of a formal process through planning, design, installation and use.

The process however can often be protracted over long lengths of time due to number of factors e.g. planning permission delays, design change, or cost benefit shortfalls with a consequential loss of risk management cohesion along the way.

As a result it is natural that concern could be raised part way or by introduction of a new stakeholder if clear sight of the risk management controls taken are not readily available in an understandable way.

With the above in mind, this report considers two views of the arrangements for managing risks associated with provision of wind turbines to allow for a comparison with our current provisions;

Risk management view	Approach
<b>Objective risk</b> i.e. technical aspects	Steps taken to identify and design out technical, legal/physical risks (e.g. flicker, noise), potential for mechanical breakdown.
<b>Perception risk</b> i.e. expectation and understanding	Steps taken with stakeholders for communication of, and understanding of, actions taken to ensure risks are reduced as far as is reasonably practical and consideration of the appetite for acceptance of any remaining risk albeit how small or remote that risk may be.

### a) Objective risk

The list below covers the main controls to manage **physical and technical** risks associated with provision of wind turbines;

- (i) Selection and use of a [Microgeneration Certification Scheme](#) (MCF) approved turbine
- (ii) Selection and use of a MCF approved Installer and assessed (health and safety competent and resourced) project team with proven experience in wind turbines
- (iii) Install in accordance with MCF Installers Guidance
- (iv) Inspection and maintenance regime provided covering: -
  - o Identification of life expiry of key components/equipment
  - o Funding for whole life use/replacement
  - o Provision of a servicing and maintenance contract
  - o Ready access to H&S File and Building Manual information
- (v) Complete all legal measures; Planning; Building Warrant, etc
- (vi) Mitigate preventative risks – site specific risk assessment covering all key hazards\*.

Each of the listed controls can be recorded on a **register** with progress/status tracked.

In respect of the last point above, good positioning of wind turbines in the context of site specific factors and interaction with any persons is one of the key risks to be managed.

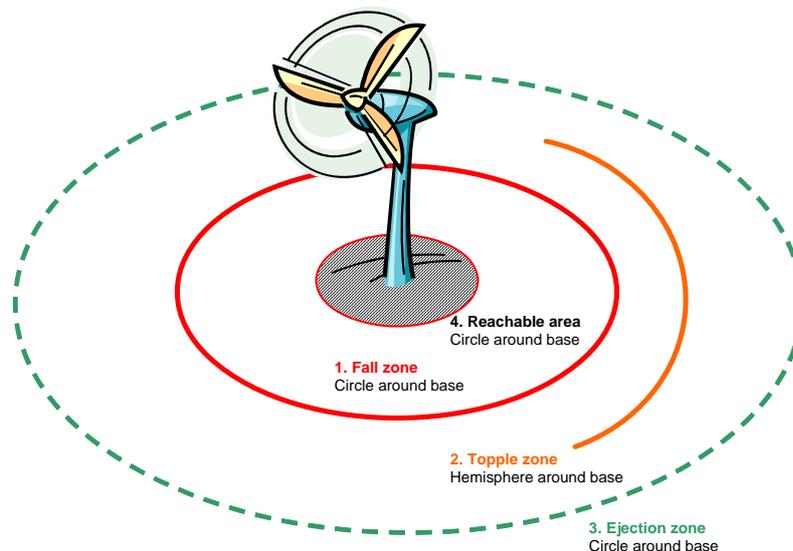
By considering potential equipment or component failure outcomes or other foreseeable events a Safety Buffer Zone diagram\* (see overleaf) could be prepared for use in option appraisal and to inform decisions on location.

**Safety buffer zones** plotted on a plan can be a good visual way of showing the relationship and proximity of site activities / use of spaces to a proposed wind turbine location with safety criteria;

Zone	Extent	Typical hazard
1	Circle around base	Fall zone: Hazard if anything fell from turbine
2	Hemisphere around base	Topple zone: Hazard if the mast were to topple
3	Circle around base	Ejection zone: Hazard if something were to be ejected from the spinning rotor
4	Reachable area	Vandalism: Lowest point of rotating parts above the ground/easily accessible point
5	Varies	Impact: Hazard from vehicle impacts

The risk assessment(s) carried out should consider at least the following hazards:

- Falling objects — anything that can fall from the turbine including structural or mechanical parts or natural phenomena (e.g. ice);
- Tower/mast failure — the potential for structural failure leading to a full or partial collapse of the tower/mast;
- Thrown or ejected objects — anything that could be thrown or ejected from the rotating blades including structural or mechanical parts or natural phenomena (e.g. ice)
- Dangerous mechanical parts — potential or accidental or intentional contact with rotating parts taking account lowest point of rotating parts and any points that are easily accessible;
- Electrical – potential for accidental or intentional contact with electricity including underground services
- Slips/trips/falls- potential for slip trip and falls associated with the turbine including the location of wires guy ropes etc.



\*Safety Buffer Zone diagram - A suitable buffer zone could be considered within any building or school site to inform location

Note: As the optimum location of a wind turbine will depend on a number of factors; visual impact, efficiency/effectiveness of energy production, economical/performance benefit/most advantageous location, including safety, a consensus for approval or viability may not be reached to allow the project to proceed.

## b) Risk Perception

Expectation and understanding

Wind turbine installation in property establishments is a relatively new venture for Highland Council. With 12 turbines installed so far and only one incident (Rasaay Primary during a pilot phase) expectations are high that this form of energy production will make significant contribution to reduce our carbon footprint. With such a positive desire and interest from across the range of stakeholders the appetite for provision of more installations is buoyant.

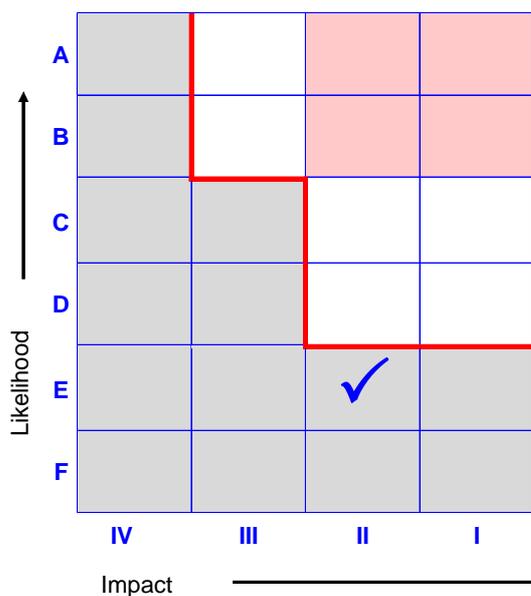
From consideration of the information in previous sections of this report the risk of a wind turbine failure leading to harm is very low. As outlined though this is very dependant on;

- having the right, competent people in the team
- doing everything that should be done in the right order
- the interaction of the Engineer leading the team, Responsible Premises Officer, Installing contractor, CDM Co-ordinator and Maintenance, cleaning and servicing contractors to assess and manage risks that they are best able to control, and turbines have
- good sighting – not a one-way decision, involves interaction with community/occupiers and consultation with stakeholders.

The reduction in **likelihood** of an incident occurring can be based on 'Objective' risk criteria. The reduction in **consequences** of any failure should it occur leading to a harm event will be due to the;

- size of turbine, distance / mass of part that fails, distance failed part has to travel, and
- likelihood of a person being present (and at the time of failure) and being struck by the failed part(s).

**Risk Matrix – Provision of Wind Turbine**

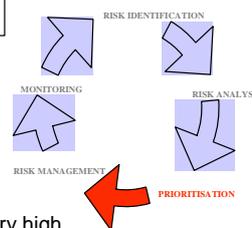


**Likelihood:**

- A Very high
- B High
- C Significant
- D Low
- E Very low
- F Almost impossible

**Impact:**

- I Catastrophic
- II Critical
- III Marginal
- IV Negligible



Zurich Municipal Management Services

The risk matrix diagram above offers to illustrate in general terms that whilst a balance of a very low likelihood with a critical consequence (should the harm event occur) is below a tolerance line it would be sensible to ‘do a bit more’ where expectations on safe use of this new technology, especially where turbines within school establishments are planned, are high. One area where certainty on likelihood can be refined is to know more about failure rates and estimates of the risk to persons should they occur.

To consider this aspect further requires more in depth knowledge on the factors that could inform / lead to a risk from harm actually occurring. The HSE has recently commissioned a report from MMI Engineering Ltd to study and develop a methodology for the estimation of the risk of harm to persons in the vicinity of wind turbines. The report opinions and/or conclusions expressed will be those of MMI Engineering Ltd and would not necessarily reflect HSE policy, however this information will help inform and assist with provision of guidance.

**c) HSE project to study and develop a methodology for the estimation of the risk of harm to persons in the vicinity of wind turbines**

A final draft of the HSE commissioned report (which is very detailed and technical in nature) has been reviewed and the conclusion confirmed;

- that there is little publicly available failure data for wind turbine failures
- where databases have been compiled, the data are typically held in confidence by manufactures or industrial bodies, or are compiled by pressure groups and the source data cannot be verified
- risks of fatality associated with a 2.3 MW utility scale wind turbine are not particularly high relative to other risks commonly experienced
- typically the Location Specific Individual Risk (LSIR) at two-hub-heights from the turbine is roughly equivalent to **the risk of fatality by lightning strike** in England and Wales
- smaller wind-turbines are more likely to be used in populated areas. If the frequency of failure of such devices is significantly higher, then so too will the LSIR.

Note: An extract from the report containing the Conclusion and Estimated annual risk of fatality due to impact from a blade/fragment of a large 2.3 MW wind turbine compared with other

societal risks (such as fatality from Road accidents, Construction industry) is provided in the **Appendix** for information.

The contents of the report for HSE (when finally published) also offers to take the risk assessment process forward by providing more in depth knowledge and tools to inform risk levels that could be used with specific designs.

To reduce 'Perception' risk, certainty can provide reassurance to dispel any remaining doubt;

- (i) in the case of wind turbine failure rates and better understanding of key component behaviours when failure occurs the **HSE report** could provide useful new information and methodology to inform the assessment of risk to persons in the vicinity of wind turbines
- (ii) **audits** of arrangements can be carried out to confirm that competent persons have been engaged, are performing well and that they have carried out all necessary assessments and compliance criteria successfully
- (iii) a readily accessible **register** containing the status and outcome of 'Objective' risk management – *(refer to the list (i) to (iv) in section 3(a))* would offer to show stakeholders and any member of the public that best practice and legal requirements were being followed and enhance consultation.

## Section 4 - Outcome of a review of current arrangements used by H&P

This last section of this report now looks to compare the risk management arrangements Housing and Property have taken against 'Objective' and 'Perception' approaches to provide a view of any gaps where improvements in the current process can be made.

Observations and suggested improvements for consideration are marked with numerals (i), (ii), etc.

### Locations of installed and planned wind turbines

Existing Highland Council sites where small wind turbines have been, or are to be, installed are listed in the below;

Site	Status	Distance of Wind Turbine from building
Stoer Primary School	Complete	33m
Dornoch Academy	Complete	36m
Inver Primary School	Complete	47m
Craighill Primary School	Complete	Approx. 10m
Bower Primary School	Complete	70m
Culloden Academy	Complete	135m
Crossroads Primary School	Complete	58m
Castletown Primary School	Complete	26m
Gairloch High School	Complete	123m
Pultney Town Primary	Complete	86m
South primary	Complete	93m
Hilton of Cadboll	Base installed	-
Halkirk Primary	Pending planning	-
Raddery primary	Base installed	-
Tongue Primary	Permission Granted but not installed	-
Nairn Academy	Base Installed	-
Knockbreck Primary	Permission Granted but not installed	27m
Broadford primary	Pending	-
Kinlochbervie Roads Depot	Pending	-
Durness Primary	Permission Granted but not installed	-

Site plans with dimensions from turbine locations and photographs (where available) have been reviewed together with risk assessment formats used.

#### a) Policy and risk information

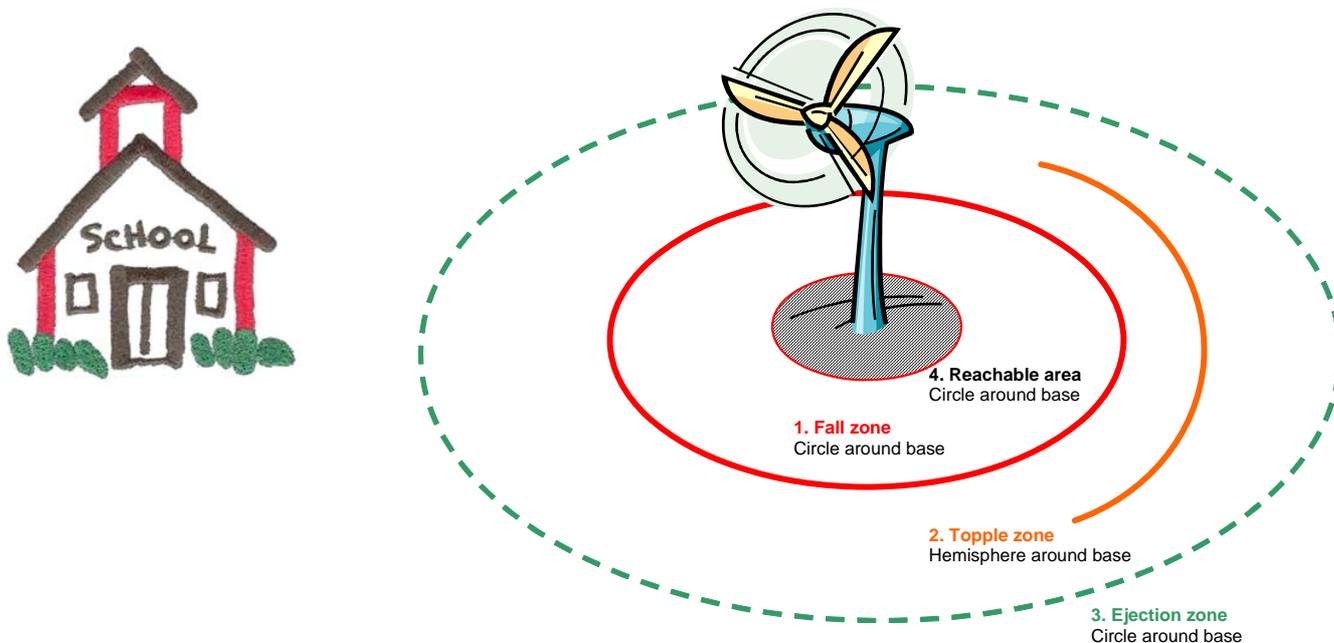
- (i) Highland Council currently has no formal policy on the provision and use of wind turbines.
- (ii) Emerging constraints have been drafted following meetings with managers of ECS and the Corporate Health and Safety Team. A copy of a paper titled 'Wind Turbines (informing policy)' prepared by the Health, Safety and Wellbeing Manager is included in the Appendix.
- (iii) Provision for auditing and monitoring has been promoted to be carried out by the Health and Safety Team. This is anticipated to cover the application of the policy requirements through the use of audits, site visits and table-top exercises.
- (iv) Existing information on wind turbine installations is held within shared folders in servers only accessible by H&P.
- (v) Various risk registers are compiled covering planning and construction risks though they are filed in separate locations.

## b) Decision making

(i) The option appraisal process could better record the decision-making process that led to final locations chosen for currently installed wind turbines.

(ii) Site / location / distance of wind turbines from buildings and areas of occupation (playing fields / carparks) requires a more visual way of displaying potential failure assessments.

The promotion of a diagram to show suitable buffer zones within any building or school site that would reduce the risk of potential falling parts should be able to be evidenced.



(iii) Safety Zones criteria

[Photoenergy](#) have recommended three levels of safety zone for example;

Zone	Zone dimensions	Guidance
1.	Mast height	Exclusion zone, marked and protected using low fence where appropriate in public places
2.	Mast height plus blade length	Low occupancy zone, maximum 4 person hours per day, no benches or shelters to encourage congregation.
3.	50 metres	Average occupancy zone, typical occupation of 240 person hours per day.

This approach takes a measured view of occupancy risk in terms of likelihood of a person being present (and being there at the time of failure) and being struck by the failed part.

(iv) In contrast the draft policy advocates a minimum separation distance between the turbine and areas of high footfall, such as occupied buildings, playing fields, frequently used roads, play areas etc. of tip height plus 10%.

(v) If introduced this policy aspect would require a reappraisal of a number of existing turbine locations which are adjacent to carpark/playing field edges (e.g. Dornoch Academy, Stoer Primary School).

### c) Safety information

(i) A site specific **Safety Statement** is recommended to be developed and maintained to contain summaries of the steps taken to identify and reduce hazards and risks associated with the;

- Location of wind turbine
- Design of wind turbine
- Installation of wind turbine
- Maintenance and
- Use of wind turbine.

(ii) Potential failure covering all site specific aspects should be covered in the H&S File. H&S Files have been provided for installed turbines however they were not readily available and their content has not been peer reviewed.

(iii) Risk mitigation measures should include site rules with adequate signage.

### d) Maintenance

(i) Current maintenance regimes are adhoc in terms of formal arrangements. Maintenance and servicing is being carried out via instructions to the installing contractor. Plans for a region wide contract are in preparation though no target timeframe for implementation has been set.

(ii) Funding for maintenance of wind turbines is contained within current revenue budgets. Whilst funding from revenue will always be available for repairs, life cycle costing has not been factored into budgets and replacement of equipment and components will be on a run to failure basis unless a planned preventative maintenance programme can be developed.

(iii) Routine visual checks (e.g. role of RPO, site staff and area Maintenance Officer are to be defined) to enable early warning of any variation in turbine operation.

### e) Communication

(i) Maintaining an active **stakeholder list** from the earliest stage right through to operation would assist in keeping everyone involved up to date with policy development, progress and process status

(ii) **Audit** outcomes of risk management arrangements and the establishment of a **register** containing the status of 'Objective' risk management – *(refer to the list (i) to (iv) in section 3(a))* would offer to show stakeholders and any member of the public that best practice and legal requirements were being followed and enhance consultation.

(iii) Collating feedback (positive as well as any negative) from stakeholders and the public can provide evidence of the effectiveness of the risk management process.

## **Summary and conclusion**

In summary and in response to concern about the adequacy of managing risks of locating wind turbines in schools in areas where people pass below or take part in sports;

- Housing and Property are considering and completing key 'Objective' risk requirements i.e. covering the main controls to manage physical and technical risks associated with provision of wind turbines. This is carried out using established risk management techniques associated with formal processes covering planning permission, building warrant, construction design and management which are legal requirements.
- Arrangements to enhance risk assessment, option appraisal/decision making and location of wind turbines can be improved through the use of emerging new guidance, completion and introduction of corporate policy on wind turbines, making information more accessible, use of safety zone diagrams, safety statements and a combined risk register. These measures would also provide reassurance to those requiring a better understanding of 'Perceived' risk.
- Observations and suggested improvements also offer to assist in clarifying the steps that have been taken but not recorded to evidence risk management.
- The review conclusion supports continuation of the wind turbine programme progression in parallel with consideration of the suggested improvements outlined in section 4(a) to (e).

*Stuart Duncan, Property Risk Management Officer, Housing and Property Service*

## **Appendix**

1. Reference information
2. CONCLUSION of Study and Development of a Methodology for the Estimation of the Risk and Harm to Persons in the Vicinity of Wind Turbines
3. Estimated annual risk of fatality due to impact from a blade/fragment of a large 2.3 MW wind turbine compared with other societal risks
4. Wind Turbines (informing policy)

## 1. Reference information

Document title	Contents
<p><b>Small Wind Turbine Performance and Safety Standard</b> British Wind Energy Association 29 Feb 2008</p>	<p>This performance and safety standard provides a method for evaluation of wind turbine systems in terms of safety, reliability, power performance, and acoustic characteristics. This standard for small wind turbines is derived largely from existing international wind turbine standards developed under the auspices of the International Electrotechnical Commission (IEC).</p>
<p><b>Common concerns about wind power</b> Centre for Sustainable Energy May 2011</p>	<p>Evidence-based analysis that draws on peer-reviewed academic research and publicly funded studies to address issues such as bird-strike, shadow flicker, noise, impact on property prices and 'wind turbine syndrome'.</p>
<p><b>Installing small wind-powered electricity generating systems</b> Energy Efficiency Best Practice in Housing November 2004</p>	<p>This guide aims to provide system designers and installers with sufficient information to ensure that small wind energy systems comply with current UK standards and with industry Best Practice. 'Small' in this context means between about 500W and 25kW output, though most parts of this guide also apply to systems of other sizes.</p>
<p><b>Installation Risk Assessment</b> Proven Energy November 2005</p>	<p>This document gives Proven Energy Ltd's recommendations for health and safety issues which should be considered prior to installation in public places. Examples of this type of project are installations in;</p> <ul style="list-style-type: none"> <li>• Schools</li> <li>• Car parks</li> <li>• Sports and leisure centres</li> </ul> <p>Or anywhere the general public might be in close proximity to the turbine on a regular basis.</p>

## **2. (Final Draft – not yet published) CONCLUSION of Study and Development of a Methodology for the Estimation of the Risk and Harm to Persons in the Vicinity of Wind Turbines**

MMI Engineering has carried out a wide ranging study to investigate the issues surrounding the potential for harm to persons in the vicinity of onshore wind turbines and to develop a methodology to estimate the risk to persons.

A literature survey has been carried out to investigate the current status of available data for wind turbine failure rates. This has confirmed that there is little publically available failure data for wind turbine failures. Where databases have been compiled, the data are typically held in confidence by manufactures or industrial bodies, or are compiled by pressure groups and the source data cannot be verified. A number of recent wind turbine incidents in the UK involving blade throw have had more thorough investigation and the results, although not available publically, are available to HSE. The UK trade and professional body for wind power, RenewableUK, has maintained a “lessons learnt” database since 2006 which has the potential to become an important resource for wind turbine failure rates.

The US National Renewable Energy Laboratory has contributed to this project in providing detail on wind turbine design, manufacture and failure modes. This highlights the range of safety features installed on most modern utility scale wind turbines which have the potential to detect incipient problems and take the wind turbine out of service before blade detachment or fragmentation occurs. There is the potential that this information may reduce the failure rate in any root-cause analysis undertaken for failure rates (which has been outside the scope of this project).

To develop the methodology for the assessment of risk to persons in the vicinity of wind turbines MMI has adopted a “cautious best estimate” approach under the guidance of HSE. This approach has been necessary as there is insufficient data on wind turbine failures to fully validate the model produced.

MMI has developed models for human vulnerability to direct and indirect impact by wind turbine blades and fragments. These models have been combined with a harm transmission model – essentially a calculation of thrown blade or fragment trajectory. In combination these models provide the methodology for the assessment of risk to persons in the vicinity of wind turbines.

The methodology has been coded in Microsoft Excel using VBA scripts and is available to HSE; the code is named MMI-RAPTur (Risk Analysis Package for wind Turbine Failure). It allows the user to define the specific details of a wind turbine’s design, wind data and other variables specific to a particular failure to be investigated. The code uses a Monte Carlo algorithm to calculate a large sample of failure events, which are analysed to provide: probability of a blade or fragment landing at a particular location; probability of fatality due to direct impact on individuals in the open and probability of fatality due to indirect impact on individuals within buildings. These probabilities of fatality can be considered as *conditional* Location Specific Individual Risk (LSIR), where the condition is that blade failure has already occurred. If multiplied by a known or estimated blade frequency of failure, the probabilities of fatality can then be interpreted as Location Specific Individual Risk.

A single case study was carried out with the risk assessment methodology to determine typical risks associated with wind turbines and to compare the results with other societal risks. This has used the example of a 2.3 MW utility scale wind turbine. The analysis has indicated that the risks of fatality associated with this wind turbine are not particularly high relative to other risks commonly experienced. Typically the LSIR at two-hub-heights from the turbine is roughly equivalent to the risk of fatality by lightning strike in England and Wales.

Although this low level might be considered acceptable, it should be borne in mind that it represents a single large, horizontal axis, utility-scale device. Smaller wind-turbines are more likely to be used in populated areas. If the frequency of failure of such devices is significantly higher, then so too will the LSIR.

Similarly where turbines are to be placed in proximity with other hazardous installations, the potential for wind turbine fragments causing incidents on the hazardous plant should be considered. Whilst the case for allowing such developments could most likely be made, it would be prudent not to allow wind farms to be developed within range of such plant without detailed consideration on a case by case basis.

### 3. Estimated annual risk of fatality due to impact from a blade/fragment of a large 2.3 MW wind turbine compared with other societal risks

<i>Source of Fatality</i>	<i>Annual Risk</i>	<i>Assumptions</i>
Wind turbine - Direct impact by blade/fragment	10 <sup>-9</sup>	At 2x hub height from wind turbine
Wind turbine - Indirect impact by blade/fragment	10 <sup>-8</sup>	At 2x hub height from wind turbine
Cancer	2.58 x10 <sup>-3</sup>	Averaged over population. England & Wales 1999
Lightning	5.35 x10 <sup>-8</sup>	England & Wales 1995-1999
Mining Industry	1.09 x10 <sup>-4</sup>	GB 1996-2001
Construction Industry	5.88 x10 <sup>-5</sup>	GB 1996-2001
Agriculture	5.81 x10 <sup>-5</sup>	GB 1996-2001
Service Industry	3.00 x10 <sup>-6</sup>	GB 1996-2001
Fairground Rides	4.79 x10 <sup>-9</sup>	Assumes 4x rides per annum. UK 1996-2000
Road Accidents (all forms)	5.95 x10 <sup>-5</sup>	UK 1999
Rail Travel Accidents (per passenger journeys)	2.32 x10 <sup>-8</sup>	Fatality per passenger journeys GB 1996-1997
Rail Travel Accidents (annual risk - commuter)	1.05 x10 <sup>-5</sup>	Annual risk of fatality: 2 daily journeys, 45 weeks per year
Aircraft Accident (per passenger journeys)	8.00 x10 <sup>-9</sup>	Fatality per passenger journeys UK 1991-2000
Aircraft Accident (annual risk – holidaymaker)	1.60 x10 <sup>-8</sup>	Annual risk of fatality: 2 flights per annum

## 4. Wind Turbines (informing policy)

This paper details the expectations from the Council's Health, Safety and Wellbeing Teams with respect to wind turbine projects at educational premises.

These expectations can be grouped into 5 distinct areas:

1. Planning stage
2. Installation phase
3. Maintenance phase
4. Operation phase
5. Managing contractors

### 1.0 Planning stage

It is essential that a health and safety risk assessment is conducted as early in the decision making process as possible. Although the risk of a passer by being injured by an object falling from a turbine (or the turbine falling over) is extremely low, it has to be accepted that the risk is not negligible. Consideration should be given to excluding school children entirely from the area.

The risk assessment should take into account as a minimum:

- Siting of turbines: ensure there is adequate distance from pathways and occupied areas (including play areas) and buildings. The area within the rotor radius around the turbine should not be used. Fencing should be considered if access is difficult to control. Separation distance between the turbine and areas of high footfall, such as occupied buildings, playing fields, frequently used roads, play areas etc. should be a **minimum** of tip height plus 10%.
- Noise radiation
- Shadow Flicker
- Access routes (for installation and maintenance operations)
- Security
- Potential health risks

Control systems such as anti-climb devices and safety signs should also be considered.

The completed risk assessment should be submitted with the planning application to the Planning Committee.

### 2.0 Installation phase

The successful contractor (see item 5) should submit a risk assessment/safe system of work for the erection and installation phase of the project. This risk assessment must take cognisance of at least: construction related hazards (including handling, excavation, access, traffic management etc.), electrical hazards, machinery hazards, mechanical and structural failures and working at height. The Council's representative should ensure that there is a pre-work meeting to discuss and agree the safety controls in place.

Where there are multiple contractors on site work **must** be controlled by the Principal Contractor and communicated to the Council's competent representative.

All installations must be fully commissioned and have a technical sign off by the specialist prior to a handover to the Council.

### **3.0 Maintenance phase**

The maintenance contractor (see section 5) should submit a risk assessment for periodic and reactive maintenance activities which should consider, as a minimum: access routes, working at height, electrocution, school activities, etc. As with the installation phase, liaison, communication and consultation is vital and the risk assessments and safe systems of work should be submitted and verified with the Council's competent representative.

### **4.0 Operation phase**

The head teacher and the Maintenance Officer should both have access to the risk assessments and subsequent safety systems of work detailed above as this will assist the RPO to conduct/modify any local risk assessments.

### **5.0 Managing contractors**

The selection and subsequent management of suitable contractors is a key element of continuing safety. Assessment of contractor competence (including health and safety competency and awareness) in the installation, operation and maintenance of the specific type of wind turbine to be erected is of paramount importance at the selection stage(s).

Housing and Property Services (HAPS) should be consulted for advice on contractor selection and management arrangements.

### **6.0 Monitoring**

All issues with the installations should be reported to the Council's competent representative. Accidents and incidents should be reported to the Health and Safety Team.

The health and safety team will monitor the application of the above requirements through the use of audits, site visits and table-top exercises.