Assessing the Potential for an Airborne Wind Energy test-site in Ireland.

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1. Executive Summary

- 27 Airborne Wind Energy projects were surveyed to assess the requirements of a test-site. 85% of projects participated fully in the survey, including all of the established commercial and academic projects.
- 70% of respondents expressed the view that a fully equipped test-site, already designated as a fly-zone would be very useful. 30% consider that it would be somewhat useful.
- The survey results indicate that a test-site would require a landbank of 320 hectares which would allow flights to a height of 600m.
- 16 sites were assessed by GIS techniques and three were selected as best matching the defined criteria. All sites are located on raised bog areas in the central plain of Ireland.
- The strong directional bias of the wind resource in the region of the three sites suggests that higher flight heights may be achievable within the proposed test-sites.
- A test site design specific to the conditions around the identified sites has been submitted.
- Budgeted costs for two variations of the development have been provided in Appendix C/D costing €2.5m and €914k.
- The Sustainable Energy Authority of Ireland (SEAI) would have a key role to play in the development/financing of the test-site, including applications for EU funding under Framework Programme 7.
- A university would be a suitable partner for operation/management of the test-site providing HR resources as needed and linking to existing research programmes within the university, e.g. materials sciences, mechanical/aeronautical/electronic/electrical engineering.
- The University of Limerick would be the most suitable partner given proximity to the proposed test-sites and existing research strengths in relevant fields.
- The creation of either a temporary or permanent Restricted Airspace can be handled within existing IAA procedures.
- Individual AWE technologies will need to satisfy both safety and lighting requirements but will not require a certificate of airworthiness.

- Lighting requirements, as expressed by IAA, appear restrictive and an incremental approach of presenting AWE technology and discussions with other European aviation authorities will be necessary.
- SEAI are the obvious administrators in developing a longer-term strategy around airborne wind energy. In the absence of a DCENR directive, SEAI were non-committal on their possible involvement.
- Promotion of such a strategy could be best positioned through the use of existing relationships between Bord Gais and DCENR.

2. Introduction

Carbon Tracking Ltd. has been retained by Bord Gais Eireann[1] (BGE) and Statkraft[2] to undertake an assessment of the potential for a shared test-site for Airborne Wind Energy (AWE) in Ireland.

Previous work funded by BGE has highlighted the potential of airborne wind energy as one of the most exciting current developments in the renewable energy field. This report aims to advance this technology through examining the prospects of developing a shared test-site for Airborne Wind Energy (AWE) in Ireland.

Airborne wind energy involves the deployment of tethered kites, balloons or gliders where their motion can drive generators and create electricity. Airborne wind energy systems offer huge promise as the next step in wind energy development, their low-wind speed cut-in extends the range of suitable sites to areas not traditionally associated with wind energy development. In particular, the higher winds available at heights from 300m to 800m offer the potential of a greater energy resource than terrestrial wind energy resource. The low cut-in wind speed also means that such systems will operate for a higher proportion of time when compared to terrestrial wind-turbines (existing research predicts a capacity factor of 60% compared to 30% for terrestrial wind-turbines).

The prospect of airborne wind energy has attracted the attention of the science and engineering communities, articles have already appeared in the New Scientist, Scientific American (who identified AWE as a top 5 Greentech technology for the future) and the New York Times. The Norwegian state-utility Statkraft, the largest renewable energy company in Europe have identified Airborne Wind Energy as an energy technology for the future and have invested in technology development. Most prominently, Google have invested in the region of $23M in Makani, a U.S. company based in Hawaii one of the leading AWE developers. Joby Energy, based in California, has invested $5M since 2008 in developing their proprietary AWE technology.

A genuine opportunity exists for Ireland to adopt a leadership position in the development and manufacture of this nascent technology. AWE systems are not available commercially; the early-stage R&D work is being undertaken by European and U.S. start-ups and campus companies. It is a very open field embracing a broad church of design and technologies all with a common need – the availability of a turnkey test-site.

The idea of 'Greentech Zones' was recently endorsed in the report of the high-level action group on Green enterprise and a precedent has been established in the

[1] Bord Gais Eireann Corporate Website : http://www.bordgais.ie/corporate/index.jsp?p=93&n=94
[2] Statkraft, Norway : http://www.statkraft.com/about-statkraft/

development of a marine energy development sites in Galway Bay and off the N.W. Mayo coast.

A similar integrated approach will be required in developing suitable test-sites in Ireland. These test-sites will provide a service to industry players, where issues around planning, aviation, grid connection etc. will be in place ensuring that companies attracted to these zones can concentrate on product development and not trying to understand labyrinthine planning processes.

This report will be structured as follows :

- Stakeholder Consultation and Survey
- Identification and assessment of specific test-sites
- Proposed design and layout of test-sites
- Proposed Model for Development and Operation of identified test-sites
- Evaluation of Policy Options
- Definition of acceptance process with Irish Aviation Authority

A similar approach has previously been used by SEAI to enable the steady development of the ocean energy sector and more latterly the prospects for carbon capture and storage.

We believe that this report could act as a springboard to develop this industry for indigenous enterprises, act as an FDI magnet for companies throughout the world and provide a valuable service to existing and future industry players both in Ireland and abroad.

If the potential does exist to develop this industry, the final report would provide a road-map for Ireland to take a world-leading role in this renewable energy technology of the future and a development template for the airborne wind energy industry.

2.1. Carbon Tracking Ltd.

Carbon Tracking Ltd. was set up in January 2009 to provide a comprehensive range of energy-related advisory services to clients in the private and public sectors. The services cover the inter-related fields of energy-management, renewable energy technologies, energy-related emissions management, carbon-footprint analysis and sustainability reporting.

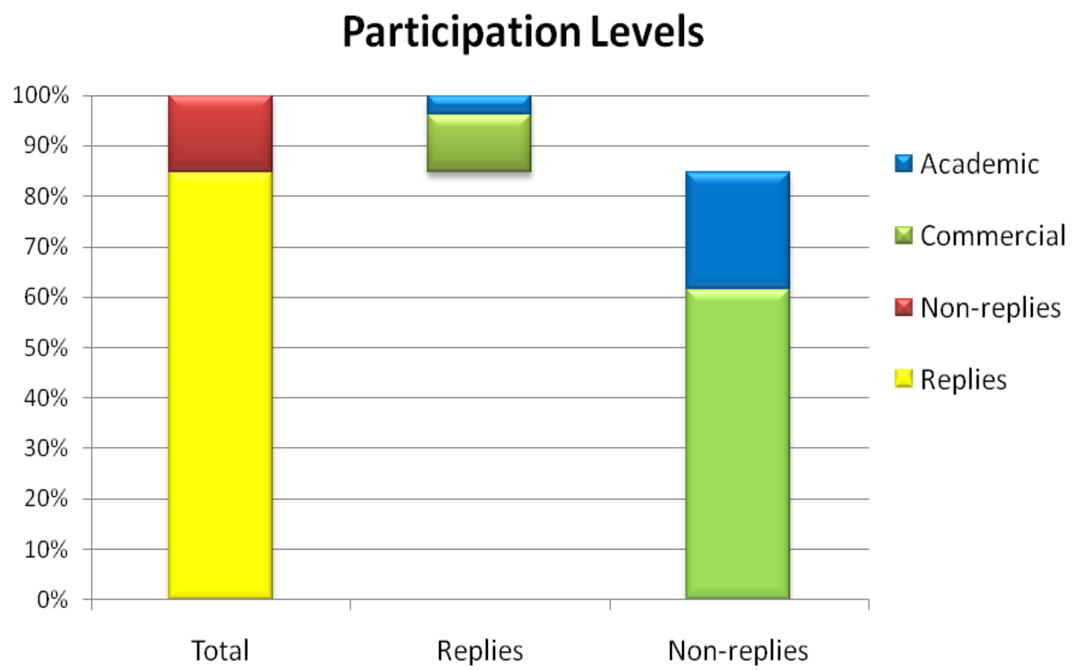
3. Stakeholder Consultation and Survey

3.1. Introduction

The long-term aim of the proposed test-site is to serve as a common facility for various commercial and academic projects who are conducting research and development in the Airborne Wind Energy sector. Since it is proposed to offer a first-class service to these projects it is imperative that all relevant stakeholders be consulted in defining the requirements of the test-site. A comprehensive survey of the various projects has been undertaken to ascertain their needs and to ensure that the test-site meets those needs.

Twenty-seven separate projects have been surveyed, nineteen commercial, 7 academic and one internet-based forum which represents a broad community of AWE supporters. The forum's responses were aggregated to represent one project.

In total twenty two projects participated fully in the survey, sixteen commercial and six academic. The sixteen commercial projects that participated included all those that have a clear product development plan and clear funding sources.



The 85% participation level required repeated contact with ~50% of participants with the other 50% participating after the initial invitation.

The question structure of the survey was such as to focus on test-site requirements of each specific project without requiring participants to divulge information which they might consider academically or commercially confidential. Only one participant, Kitemill Norway, indicated that the survey contained some questions of a confidential nature. This participant fully answered 7 of the 16 questions while the 21 other participants answered all 16 questions. This would indicate that the survey struck an acceptable balance between information gathering and confidentiality.

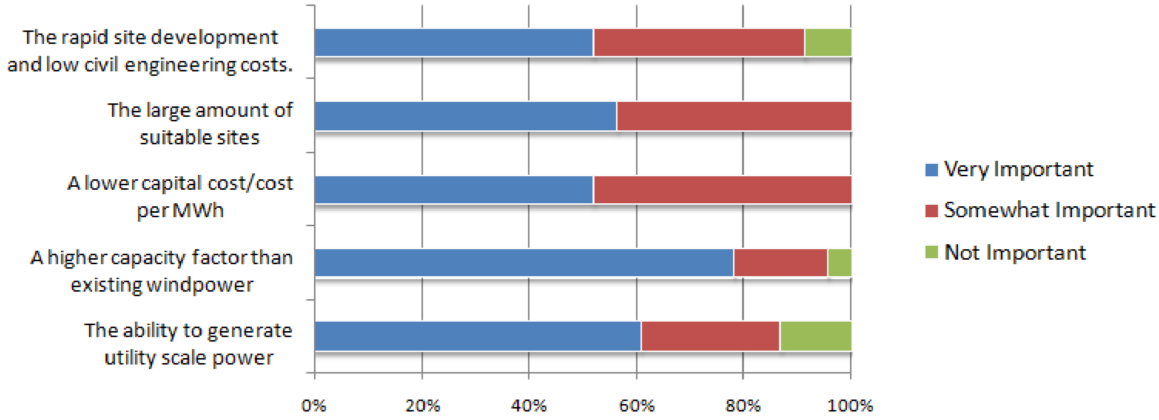
3.2. Survey Participants

Organisation	Type	Country	Response
Aeroix	Commercial	DE	YES
Ampyx Power	Commercial	NL	YES
Baseload Energy	Commercial	US	NO
CMNA Power	Commercial	US	YES
Highest Wind	Commercial	US	YES
Joby Energy	Commercial	US	YES
Kite Gen Research	Commercial	IT	YES
Kite NRG	Commercial	IT	YES
KiteMill	Commercial	NO	YES
KiteTech	Commercial	UK	NO
Magenn Power Inc.	Commercial	US	YES
Makani Power Inc.	Commercial	US	YES
NTS Energiesyteme	Commercial	DE	YES
Sequoia	Commercial	IT	YES
Sky Sails Gmbh	Commercial	DE	YES
Sky Windpower Corp	Commercial	US	YES
Skymill Energy	Commercial	US	YES
Twind	Commercial	IT	NO
Windlift LLC	Commercial	US	YES
CSU Chico	Academic	US	YES
KU Leuven	Academic	BL	YES
Rowan University	Academic	US	NO
Swiss Kite Power	Academic	CH	YES
TU Delft	Academic	NL	YES
University of Limerick	Academic	IE	YES
University of Sussex	Academic	UK	YES
AirborneWindEnergy.com	Community	US	YES

3.3. Survey Questions and Answers

Question 1 : What are the most compelling arguments for Airborne Wind Energy ?

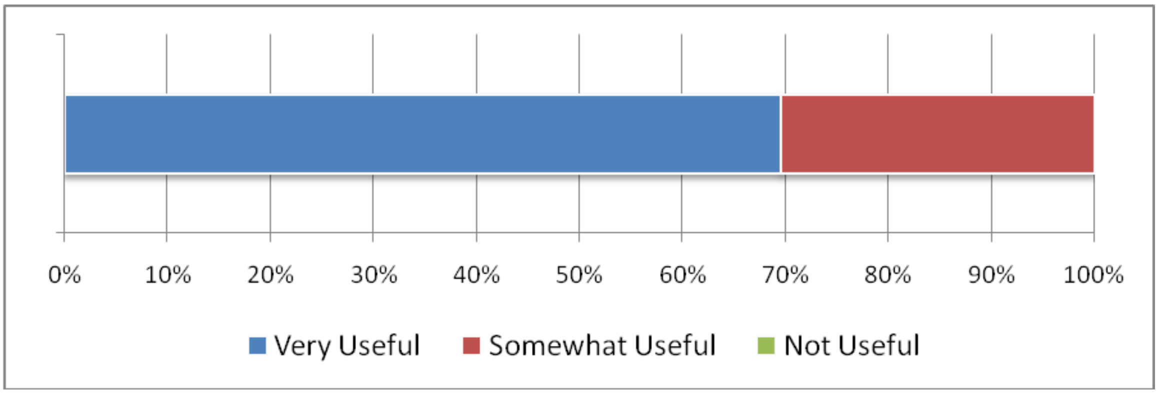
The first question sets the context for the development of AWE, asking participants to rate 5 proposed advantages of AWE and also to suggest any other advantages not listed.



Other comments included the potential for mobile applications, suitability to offshore usage and a lower environmental footprint. The lower environmental footprint encompassed lower materials requirement, hence lower embedded energy and ease of decommissioning.

Question 2 : How useful would it be for your project to have access to a fully equipped test-site, already designated as a fly-zone ?

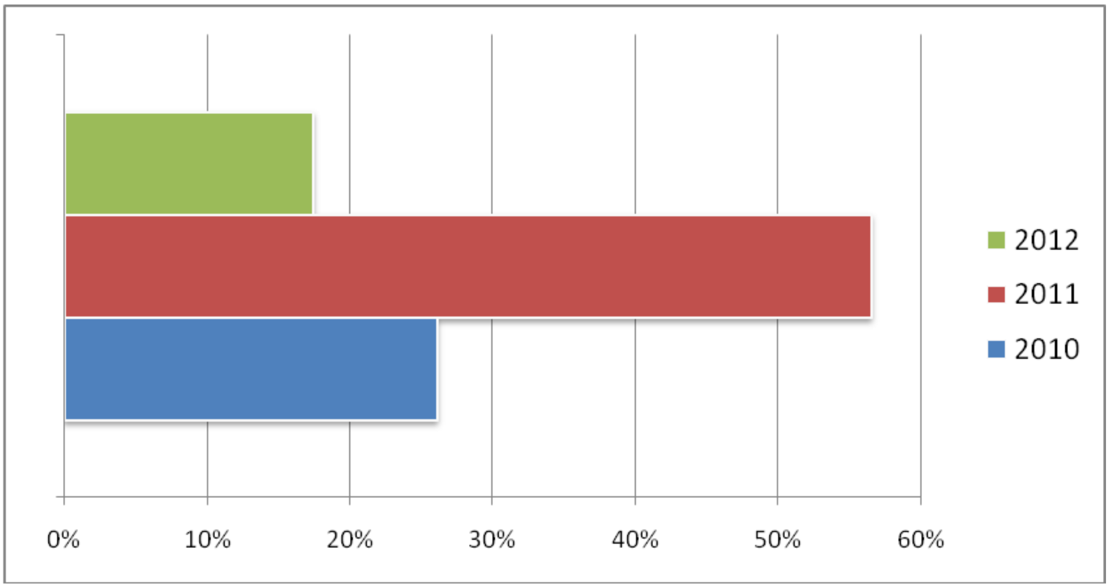
This question is used to judge the perceived usefulness of, and thus the likelihood of a project using, a fully functioning and serviced test-site.



While 100% of respondents surveyed agreed that such a test-site would be useful, the 30% which indicated that it would be "Somewhat Useful" included Magenn, Makani and Joby. This may reflect the location of a test-site in Ireland and the logistical difficulties that may propose for companies based in western USA.

Question 3 : When do you think that your project might begin using such a test-site ?

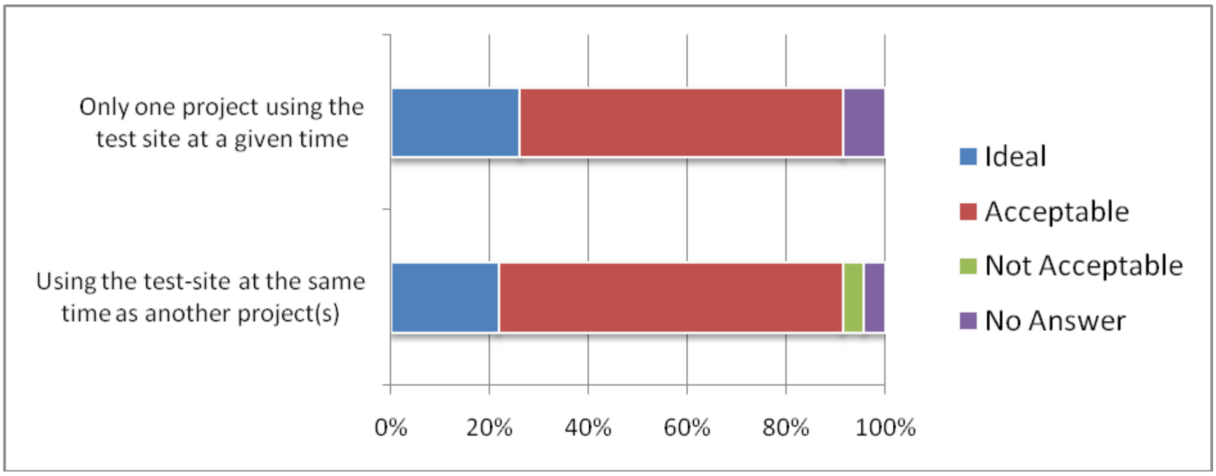
This question is used to judge the timeliness of developing a test-site and also to assess the maturity of the industry.



83% of respondents indicated that they would consider using the proposed test-site in 2010/2011. Even allowing for the inherent optimism of project proposers, this indicates a certain maturity in the projects surveyed.

Question 4 : Would your project envisage using the test-site at the same time as other projects ?

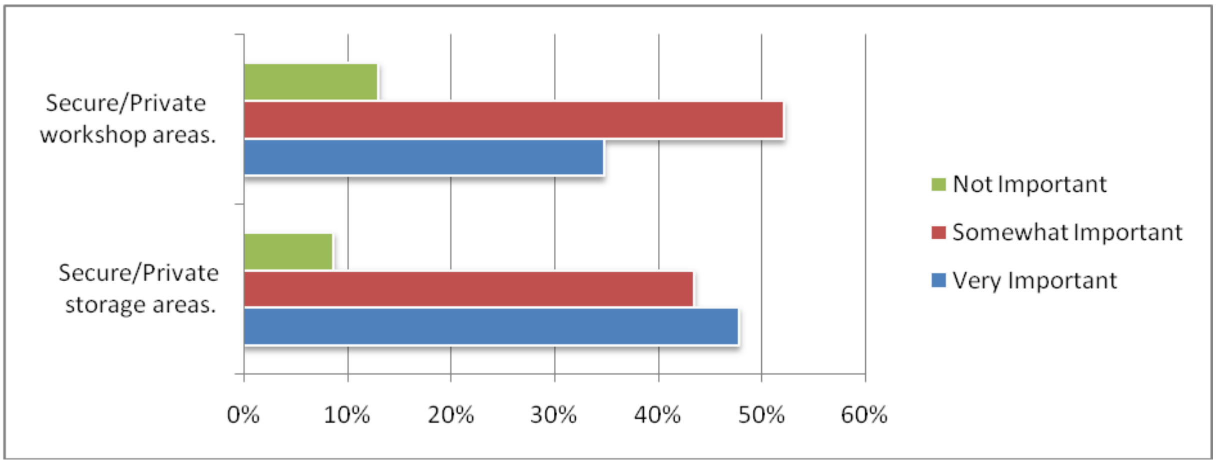
From a site development/operation viewpoint, this question assessed the willingness to use the test-site in tandem with other projects.



91% of respondents replied that sharing the test-site would be acceptable. One project, Kitemill Norway, indicated that sharing the test-site would not be acceptable, thus continuing their confidentiality concerns as expressed with the nature of the questions in the survey.

Question 5 : Where test-site sharing could be envisaged, how do you rate the importance of the following facilities ?

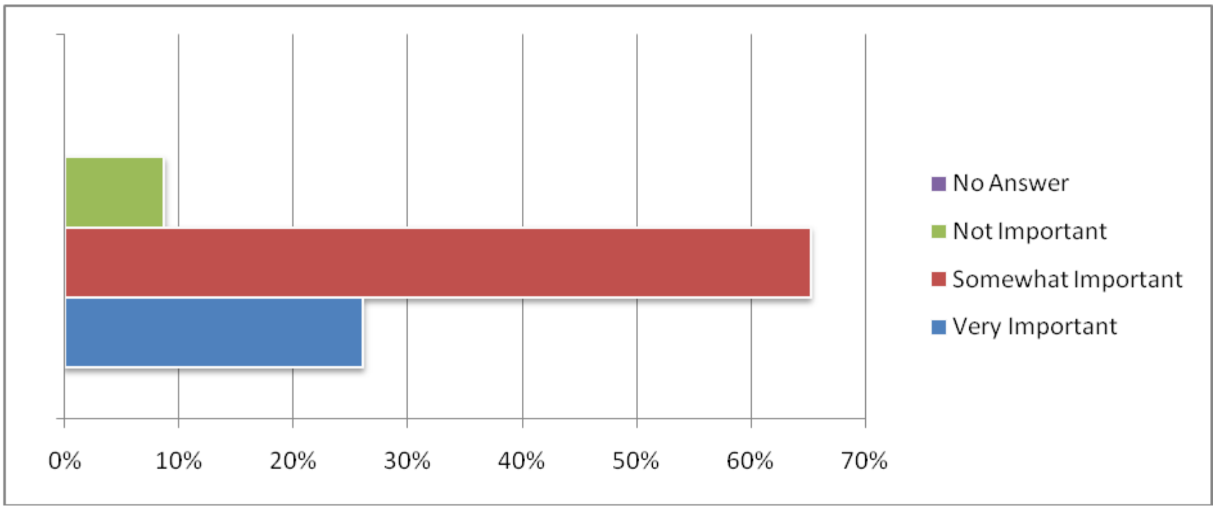
On the assumption that some form of test-site sharing would be acceptable to a majority of users, this question aimed to address any security/confidentiality concerns that potential users would have.



Secure workshop and storage areas were considered important by over 90% of respondents. When asked for other comments on the security issue, no further requirements were raised with comments limited to considering provision of other services which will be discussed in section 0.

Question 6 : How important is it to have an electricity grid connection that allows export/metering of any electricity generated ?

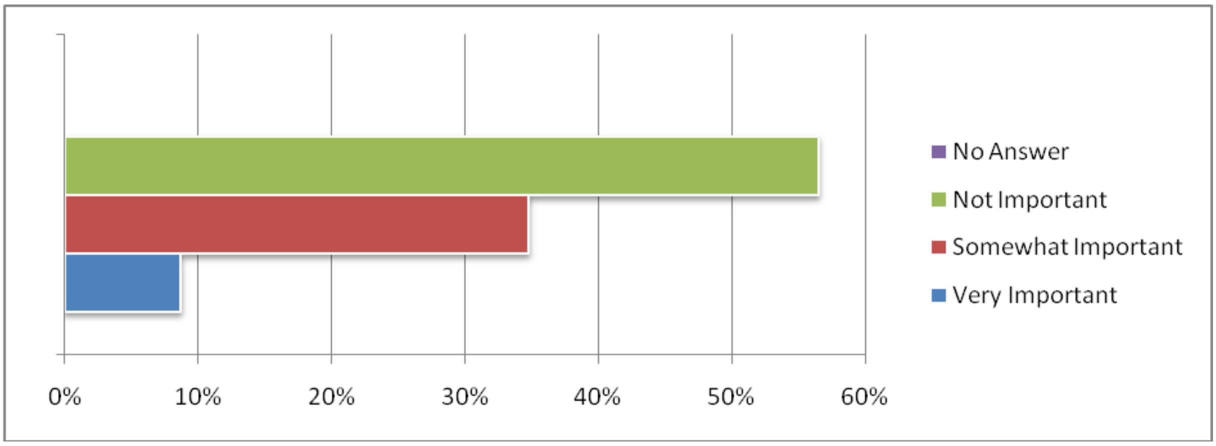
The question serves to define the importance of having a grid connection at the test-site. A metered grid-connection would serve to highlight the realistic potential of the projects, allow for revenue earnings in the case of a Feed-In-Tariff and also bring to light any issues that a specific technology might raise when connected to the grid.



The results indicate a grid connection is not of primary importance. Further comments to the question indicated that the grid-connection would be primarily seen as a method of "dumping" the electricity generated, a preferred method to the use of resistive heaters. 40% of respondents indicated that they saw a grid connection as important at later stages in development, but not at the present.

Question 7 : Would an attractive Feed In Tariff (FIT) be an important factor in deciding to use the test-site ?

The purpose of this question is to inform discussion with state agencies on the possibility of defining an FIT specifically for AWE.

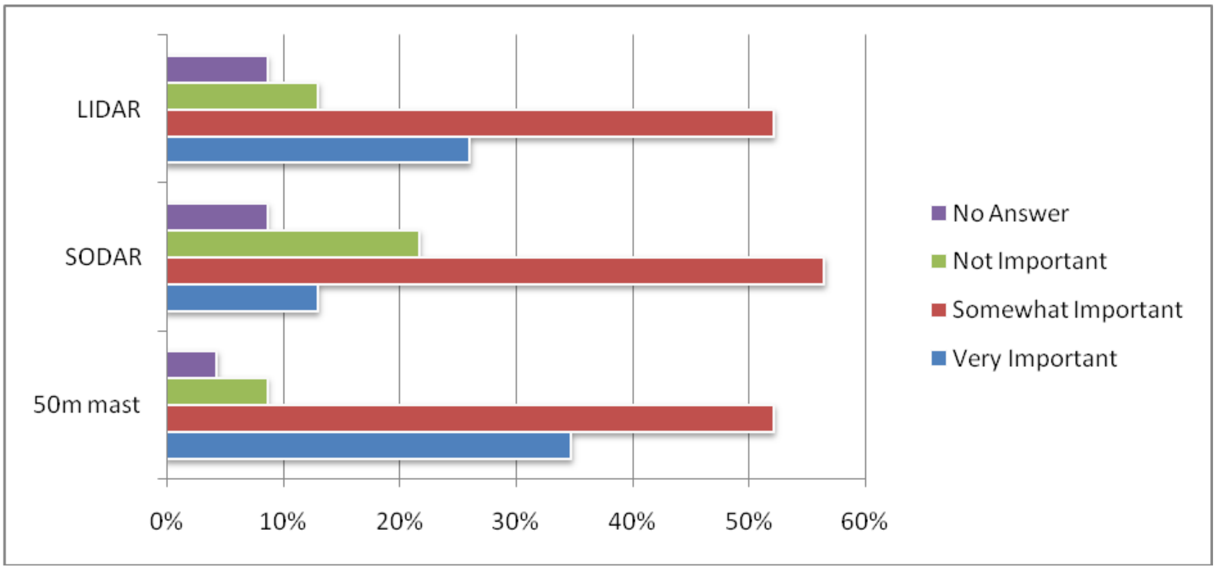


The responses followed those of the previous question with over 58% saying that an FIT was not important. Of those that did consider an FIT of importance, the level of FIT that was hoped for was in the €140-€160/MWH bracket. This is in keeping with existing FIT levels for Anaerobic Digestion and Ocean Energy.

One respondent noted that an FIT was not important from a financial viewpoint but more as a statement of government support. This echoes comments from SEAI in section 7.

Question 8 : What type of wind-measurement equipment will be required at the test-site ?

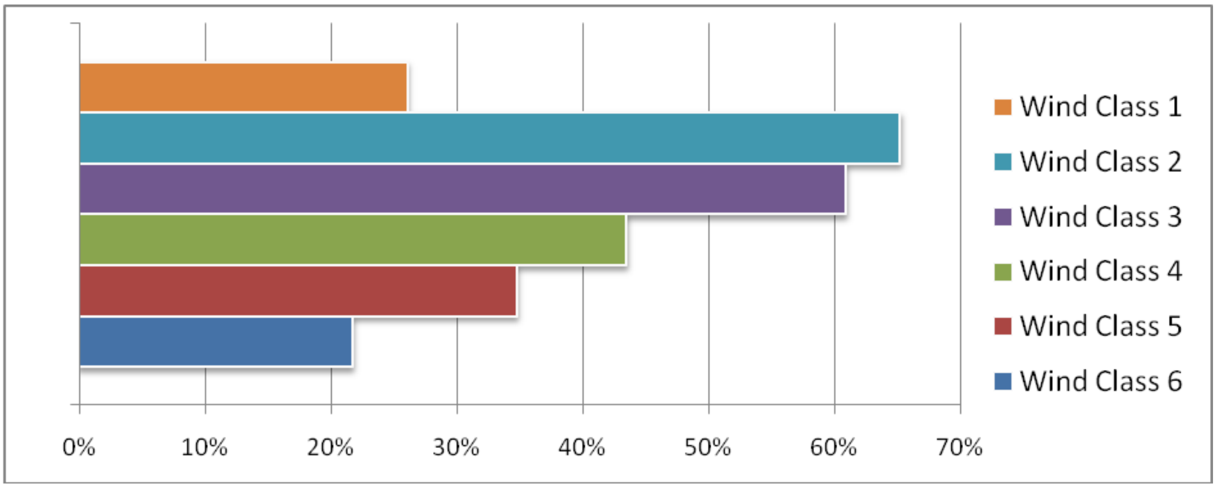
This question serves to guide the services which would be provided at the test-site.



The responses indicated that a 50m mast was important to 87% of projects with LIDAR at 78% and SODAR at 70%. Accompanying comments indicated that LIDAR/SODAR would be and either/or choice.

Question 9 : What do you judge to be the wind-speed requirements for your project ?

This question serves to define the desired wind resource at the test-site. The answers referring to wind-power class, or average wind speeds at 50m

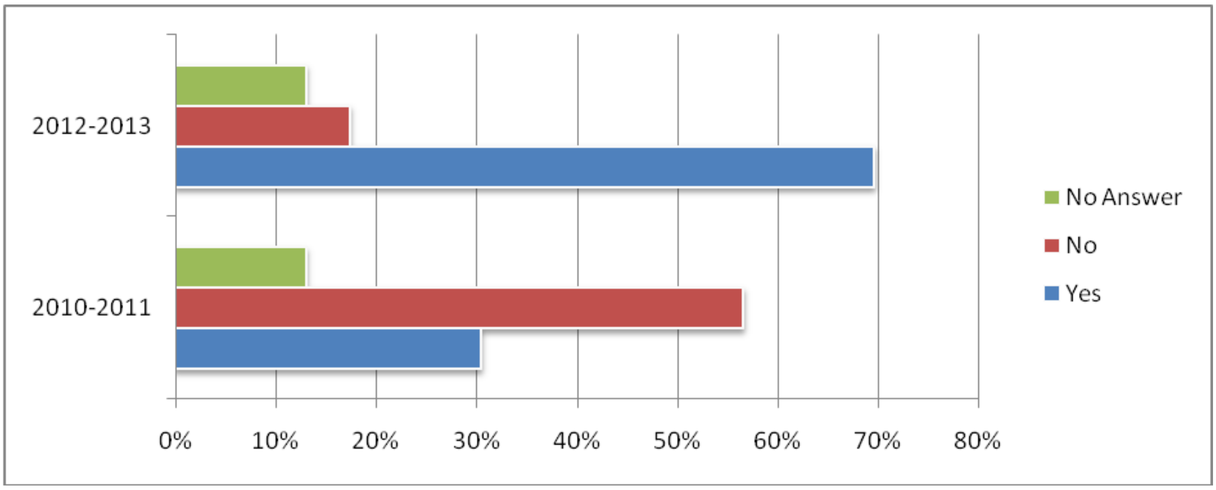


Ten of the projects selected 4 or more preferred wind-classes so the results of this question need to be taken in this context. Of the remaining projects, 11 selected wind-class 2 & 3 as being preferred. A further stage in site-selection would involve more detailed definition of wind-requirements in terms of wind-speed/direction and the acceptable variability of both.

Comments offered were wide ranging with some projects looking for a site with highly variable turbulence and wind speeds and others, more realistically, looking for stable wind-conditions increasing the likelihood of testing being carried out according to schedule.

Question 10 : Would you envisage requiring access for heavy goods vehicles to a test-site in the following periods ? (e.g. to deliver shipping container sized)

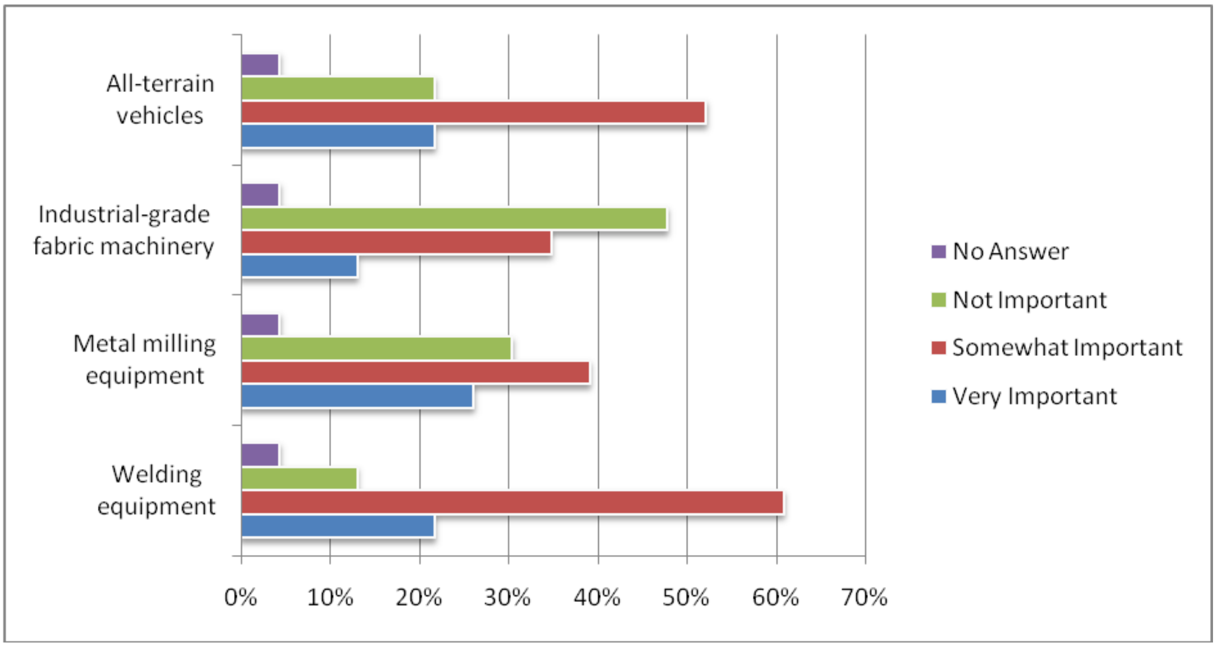
This question serves to define the type of road access that would be required to the test-site, with an impact on site-development costs.



The 30% with a requirement for shipping container access in 2010-2011 increased to 70% for 2012-2013 reflecting the projected scaling up of projects in that period. Again, the inherent optimism of the projects would lead to overstatement of the short-term requirement.

Question 11 : What type of equipment would be useful to have on-site to assist in development/repair ?

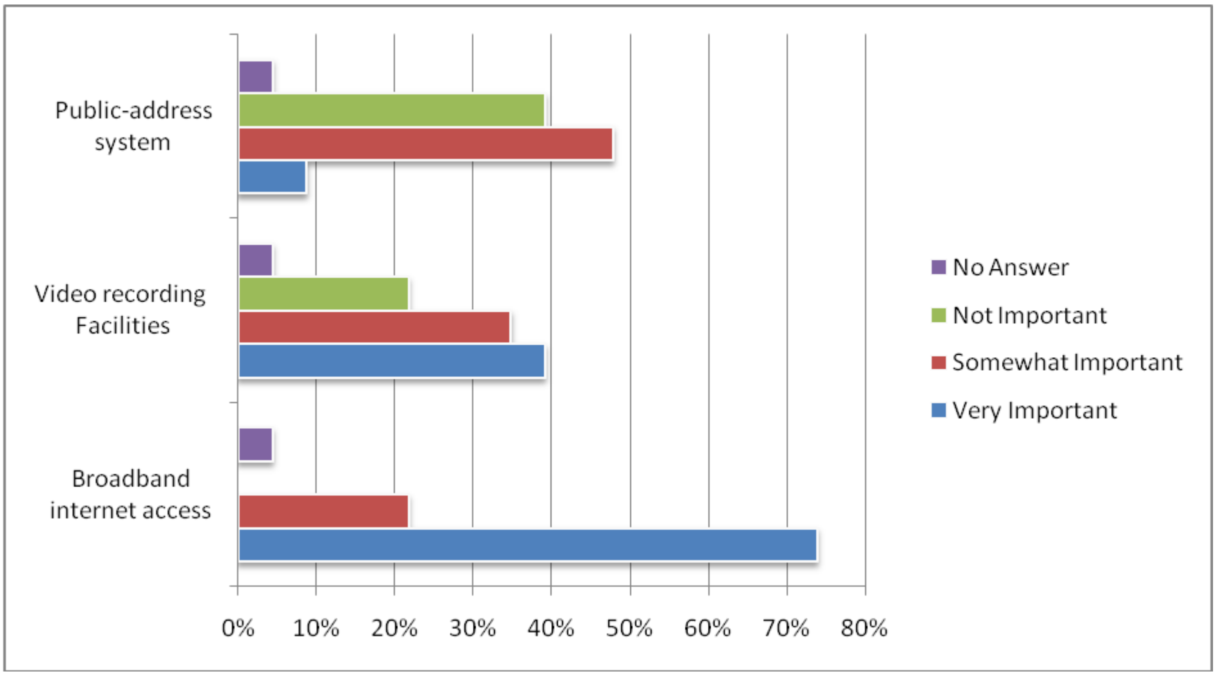
This question serves to define the equipment/services that would be required by the different projects and informs the calculations on cost of development/operation of the test-site.



The additional comments indicated that the availability of experienced local machinists/fabricators would be of benefit in order to reduce the cost of testing for projects, i.e. not needing to bring all expertise with them on-site.

Question 12 : Please indicate the importance of the following facilities at the test-site.

Again, this question serves to define the equipment/services that would be required by the different projects and informs the calculations on cost of development/operation of the test-site.

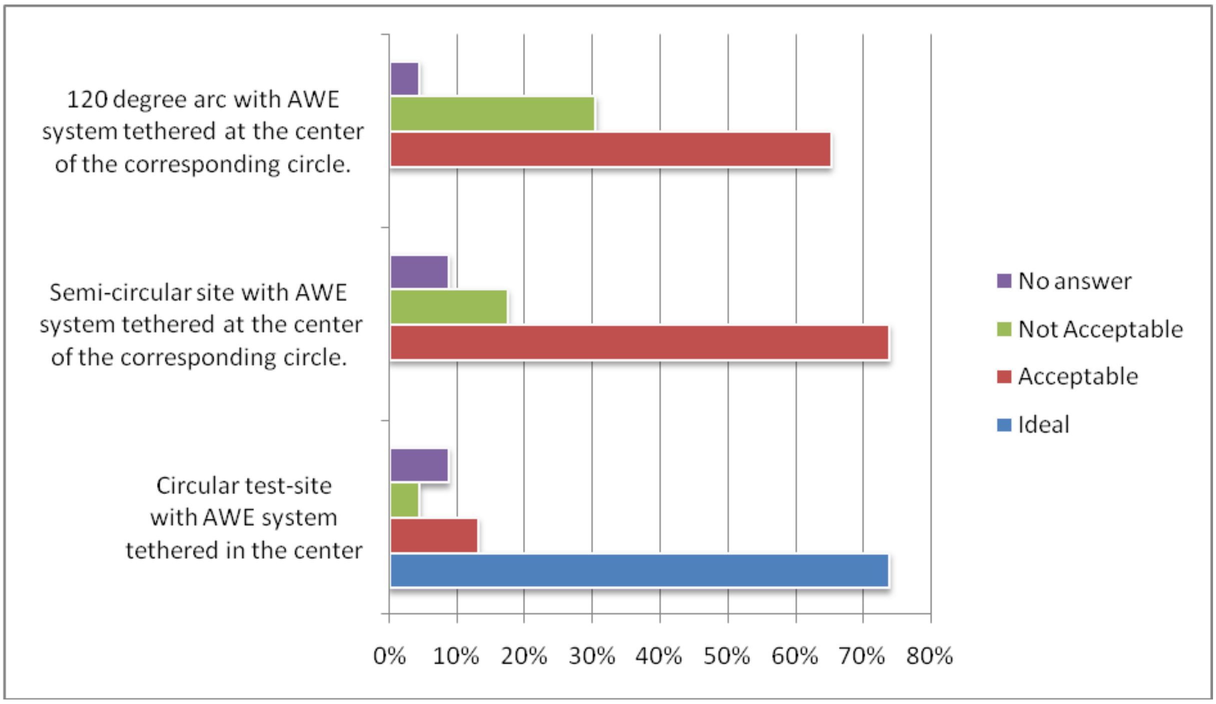


Broadband internet access is the most required facility of the three mentioned.

Additional comments indicated that basic office-space (portakabin) was acceptable and that basic on-site accommodation with be preferred to off-site accommodation.

Question 13 : How would you rate the following test-site layouts ? This has a large impact on the land-requirements.

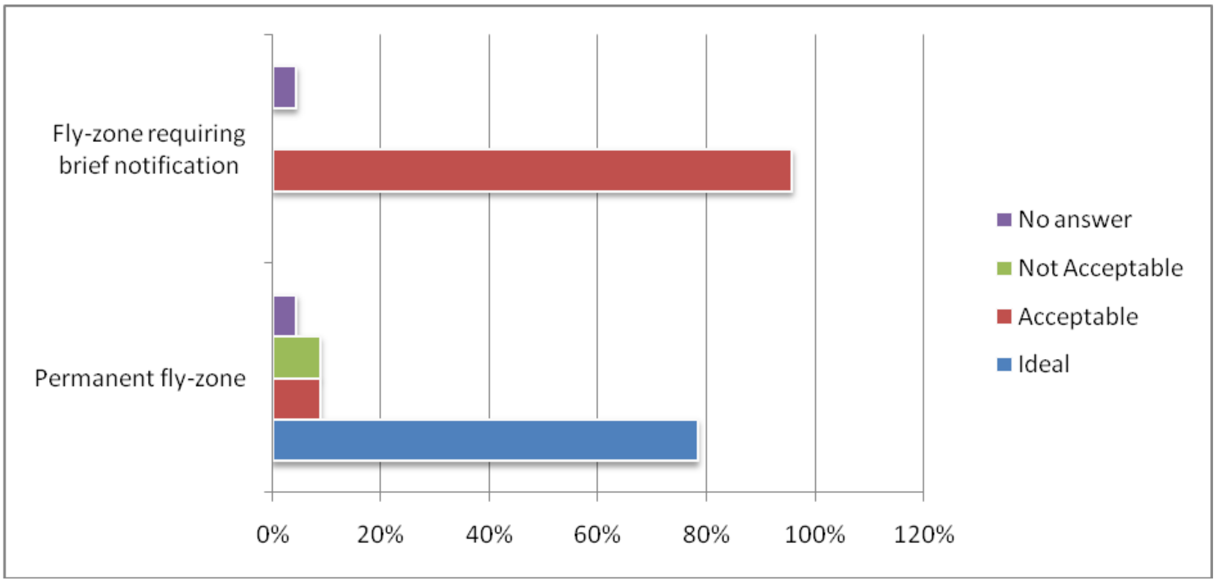
This question serves to define the search criteria for a suitable land-bank.



The more straight-forward solution, i.e. a circular test-site, was the preferred option, as would be expected. The other two options were provided for consideration in the case of a test-site with a dominant wind-direction. The advantage of these two options is a reduced land-requirement and thus a larger number of potential candidate sites. A balance must be found between the cost of the landbank and the number of days/year that a test-site projects to operate. e.g. a 120-degree arc may have suitable wind-conditions for 75% of the year but will cost only 33% or a comparable circular test-site.

Question 14 : From an aviation regulation perspective, how do you rate the following needs ?

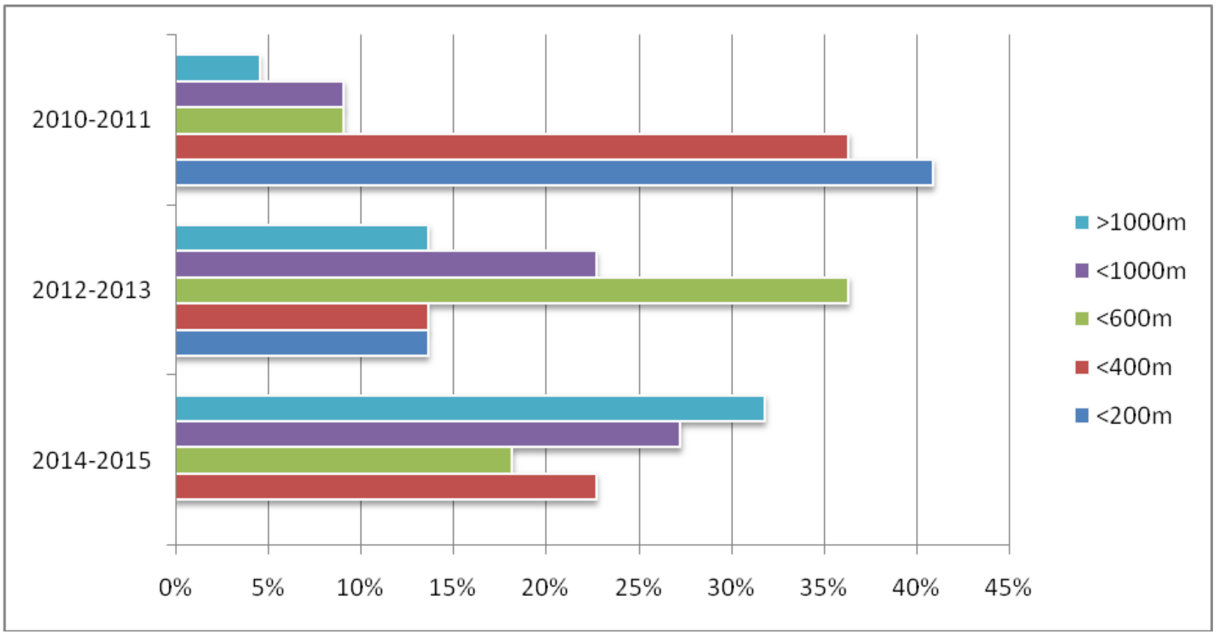
This question serves to guide discussions with the Irish Aviation Authorities.



While a permanent-fly zone was broadly seen as ideal, all respondents consider that a site requiring only brief notification to the aviation authorities was acceptable. This is discussed in greater detail in section 0.

Question 15 : How do you see your project's flying height evolving over the following periods ?

This question serves to guide discussions with the Irish Aviation Authorities and also to define the land-bank requirements for the test-site.



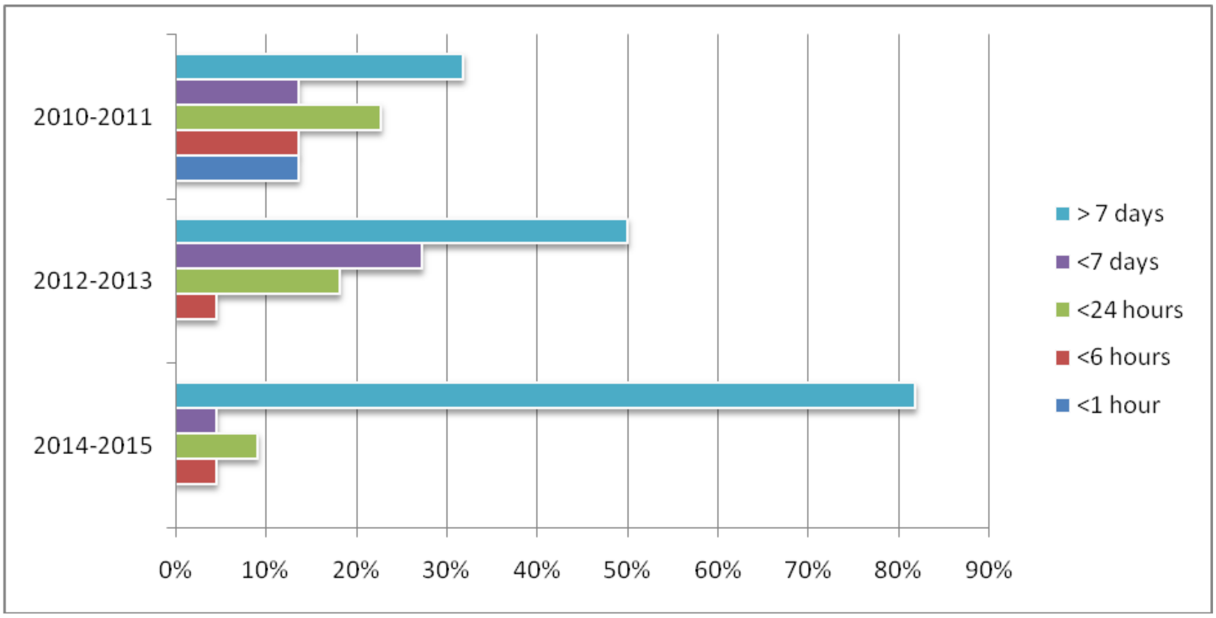
The results show that 86% of projects operate below 600m in the period 2010-11, with this dropping to 64% in 2012-13 and to 41% in 2014-2015. Similarly, 95% of projects operate below 1000m in the period 2010-11, with this dropping to 87% in 2012-13 and to 68% in 2014-2015.

The impact on landbank requirements is important. An AWE system operating at 1000m in height will require a landbank with a radius of 2000m which is the equivalent of 1256 hectares. Since a suitable test-site will be devoid of all other activity and will not contain public roads or electricity/communications lines, the larger the landbank requirements, the more difficult it becomes to find a suitable landbank.

The risk here is of choosing a test-site which is outgrown by a sizeable proportion of its potentials users within less than 5 years.

Question 16 : How do you see your project's flight-time requirements evolving over the following periods ?

This question is of importance in defining the proposed operation of the test-site



The responses predictably show a lengthening of the flight-time requirements where, by 2014, 82% of projects predict that they will be flying for periods of 7 days or greater. This directly impacts on the number of projects that can gain access to the test-site in any given year.

4. Identification and assessment of suitable landbanks

Following the detailed definition of the requirements and an understanding of their projected variation over time, the identification and assessment of suitable landbanks has been undertaken. A combination of GIS datasets, OSI data and meteorological data will be used in preliminary assessment followed by on-site visits. The requirements as defined by the survey are:

- Sites must have a radius of 1km and be circular in shape
- Urban areas to be avoided
- Proximity to 38kv electricity line, no overhead lines to traverse the site
- Proximity to local, regional and national roads
- No dwellings to be located within site
- Wind speed of site to be checked
- No significant rivers to cross the site
- No forestry within the site – or other impediments to wind flow
- No development on slopes greater than 8 degrees (<=8)
- No development within protected areas including SPA, SAC, NHA or pNHA status
- Ensure site is not located within civil/military aviation zone
- No development is permitted within the following land classes as identified within the Corine 2006 database. (See **Table 1,** Appendix B.)
- Single ownership preferable.

A summary of the GIS filtering is presented in section 0 with a more detailed description of the procedure available in Appendix B.

4.1. GIS Results and Maps

The initial GIS filter served to identify sites which met with a limited set of criteria, specifically site-size and permitted slope. This resulted in 16 sites which are detailed in Figure 1.

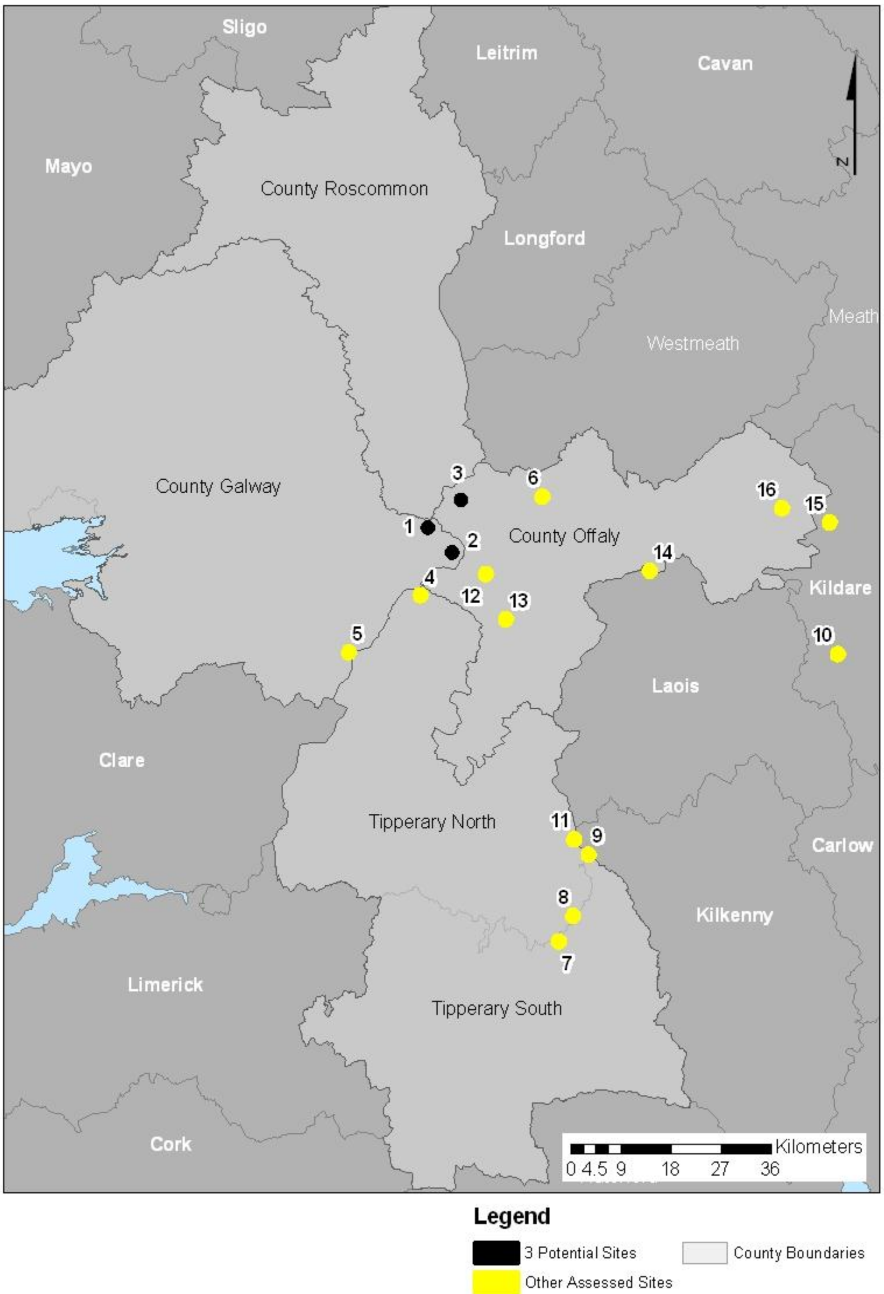


Figure 1 :Location of all assessed sites

Secondary GIS filtering was carried out using the full set of criteria which indicated that sites numbered 1,2 & 3 in Figure 1 were the most suitable. The detail of the results is included in Figure 2.

Site No.	Address	Local Authority	Existing Landuse	ESB Line through it	ESB Station	Forested Area	Road through it	Distance to Nat Road	Vaterbody	Railway	Urban Area	Vithin SAC	Vithin SPA	Vithin NHA	National Monument	Should this site be considered further ?
Site 1	Kilaltanagh, Co. Galway	Galway Co. Co.	1	No.	38kV within 1km	No	No	830m to Regional Road, 11km to N road (Cloghan), M-road 24km	Dried up portion of Grand Canal Minor Stream	No	No	No	No	No	No	Yes
Site 2	Shannonbridge, Co. Galway	Galway Co. Co.	1	No.	38kV within 1km	No	No	900m to Clonfert Local Road	Minor Stream	Industrial Peat railway tracks	No	Yes	Yes	No	No	Yes
Site 3	Aughicabe, Co. Offaly	Offaly Co. Co.	1	No.	38kV within 3km, LV line within 1km	No	No	1km	Gowlan River to east of site	No	No	No	No	No	No	Yes
Site 4	Glenbower, Co. Tipperary	Tipperary Co. Co.	1, 3	No.	38kv within 800m	No	No	600m	River Shannon to north of site.	No	No	No	No	YES	No	No
Site 5	Lough Derg, Co. Galway	Galway Co. Co.	2	No.	5km to 38kv line, 600m to LV line	No	No	1km	Lough Derg	No	no	No	No	YES	No	No
Site 6	Leabeg, Co. Offaly	Offaly Co. Co.	1	No.	1900m to 38kv line	Minor	No	700m	No	No	No	No	No	No	Yes	No
Site 7	Killeens, Co. Tipperary	S. Tipperary Co. Co.	1, 4	No.	1500m to 38kv line	Yes	No	1800m	No	No	No	No	No	No	No	No
Site 8	Derryhogan, Co. Tipperary	N. Tipperary Co. Co.	1, 4	No.	280m to 38kv line	Yes	No	1600m N8 or 350m local road	No	No	No	No	No	No	No	No
Site 9	Derryfada, Kilkenny Border	Kilkenny Co. Co.	1, 4	Minor lv at edge of site.	2km to 38kv line 230m to lv line	Yes	No	700m R502	No	No	No	No	No	No	Yes	No
Site 10	Athy, Co. Kildare	Kildare Co. Co.	1, 4		2900m to 38kv line, 680m to lv line	Yes	No	900m to local road	No	No	No	No	No	No	No	No
Site 11	Lisheen Mine, Co. Tipperary	Tipperary Co. Co.	1, 4	Yes	300m to 38kv line	Yes	Yes	Road within site	No	No	No	No	No	No	No	No
Site 12	Cancreagh, Banagher, Co. Offaly	Offaly Co. Co.	1, 2, 4	No.	350m to 38kv line	Yes	No	600m	Minor Streams	No	No	No	No	No	No	No
Site 13	Ballinadown, Birr, Co. Offaly	Offaly Co. Co.	1, 4	Minor lv at edge of site.	680m to 38kv line	Yes	No	700m	No	No	No	No	No	No	No	No
Site 14	Cush Lower, Offaly/Laois	Offaly/Laois Co. Co	1	No.	1600m to 38kv line	No	No	680m	No	No	No	No	No	No	No	Yes
Site 15	Killinthomas, Co. Kildare	Kildare Co. Co.	1, 4	No.	1700m to 38kv line	No	Yes	1700m	No	No	No	No	No	No	No	No
Site 16	Kilcumber, Co. Offaly	Offaly Co. Co.	1	No.	1km to 38kv line	No	No	960m	No	No	No	No	No	No	No	Yes

Existing Landuse Key:
1. Peat Bog
2. Water Body
3. Agriculture and Natural Vegetation
4. Coniferous Forest

Figure 2 : Full site selection criteria matrix

The three sites which provided a best-match to the criteria were numbered site 1,2 & 3 and can be seen in Figure 3.

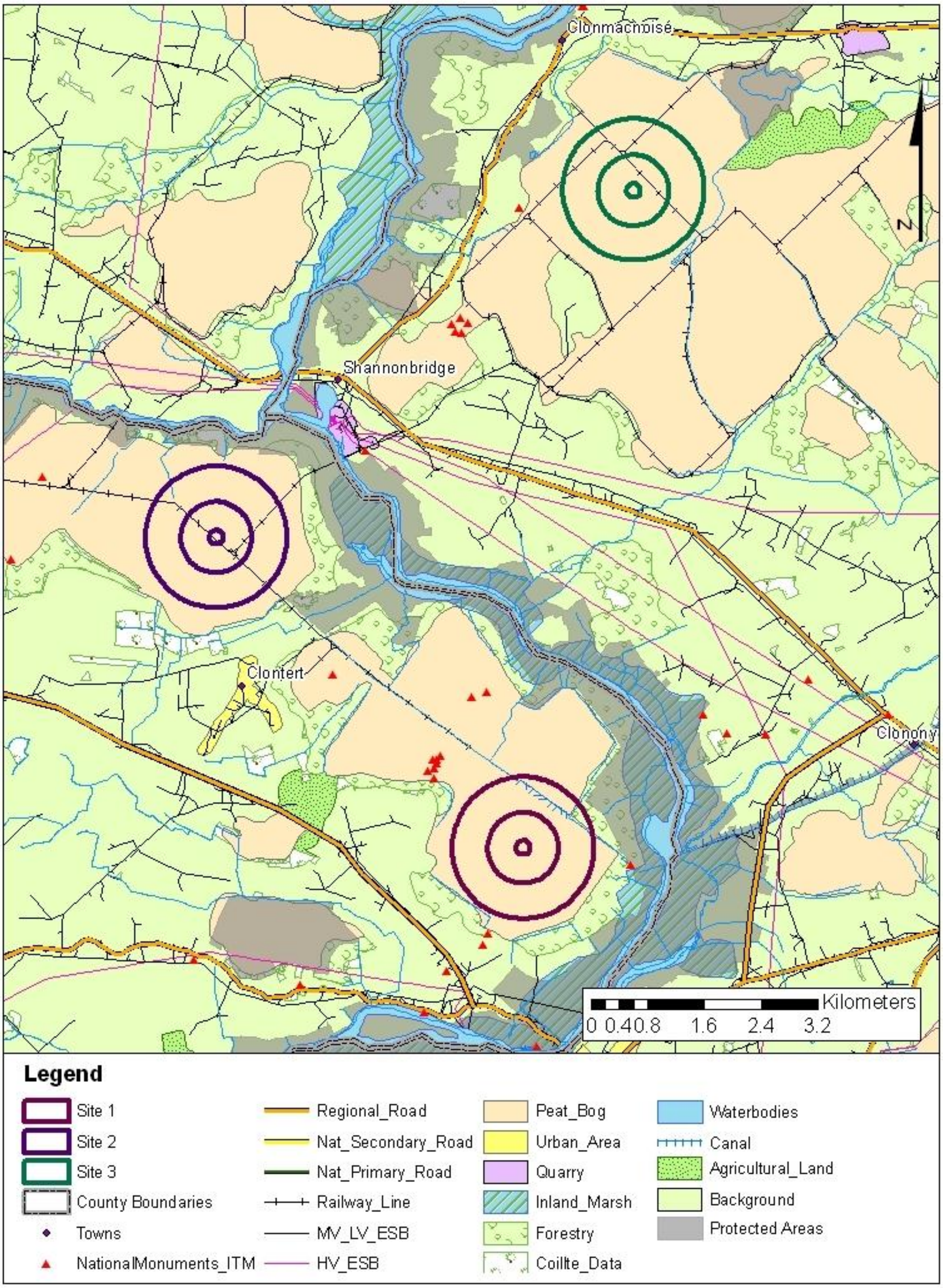


Figure 3 : Shortlisted sites

More detailed maps of all three short listed sites and the 13 other sites can be seen in Appendix B.

4.2. Wind-data Analysis

The results of question 9 in the survey (see section 3.3) indicate that 11 of the projects (50%) require a site with Class 3 wind-speeds or less. Three of the projects require Class 4 sites, three more require Class 5 sites and five projects require Class 6 sites.

It is an impossible task to find a single test-site that will meet all requirements in terms of wind-speed. All projects will require flight-time in different wind conditions depending on the stage in the development cycle they are at. Materials stress and endurance testing will have different requirements to control-systems testing, long-term operation test etc.

The three sites selected from section 4.1 all have average wind speeds[3] at 50m of 6.5~7m/s (Class 3). While there are many zones in Ireland with higher wind-speeds, the size and characteristics of the landbank required excludes the zones of highest wind-speeds. A test-site with Class 3 wind-speeds is considered for carrying out test-flights for the majority of projects, excluding requirements for testing in extreme conditions for some projects.

Since more detailed wind data was not available for the three specific sites identified, data was acquired from MET Eireann for the Birr weather station for the years 2008 and 2009. This weather station is located within 20km of all three sites. The weather station is located on the same central plain as the three sites and all three sites are sufficiently distant from large landscape features, such as mountain ranges, to allow the data from Birr to be used as a basis for analysis.

The data consists of hourly readings for wind-speed and wind-direction. The wind-speed measurements were taken from a 10m mast and the initial values have been translated to 50m values using the wind profile power-law[4], a standard method of translating wind-speeds from one height to another up to a height of 150m. Given the immediate environment of the weather station, (buildings / mature trees) the wind-speed values can be considered of medium quality and under-estimate the wind speed at the site. The data gives and average wind-speed at the weather station of 4.7m/s at a height of 50m. The Birr weather station dates from a time before detailed wind-speed data became a valuable commodity. A ratio of 4.7:6.5 is used to adjust the Birr wind-speed data to reflect the wind-speed data from the SEAI Wind Map of Ireland3.

Wind Direction Analysis

It is useful to analyse the wind-direction data acquired as this data will impact on the test-site layout and operation. The following figure, referred to as a wind-rose, graphically illustrates the directional distribution of the wind at the weather station and also indicates the proportionate occurrence of different wind-speeds for each directional segment.

[3] SEAI Wind Map of Ireland : http://maps.sei.ie/wind/
[4] Wind Profile Power Law : http://en.wikipedia.org/wiki/Wind_profile_power_law

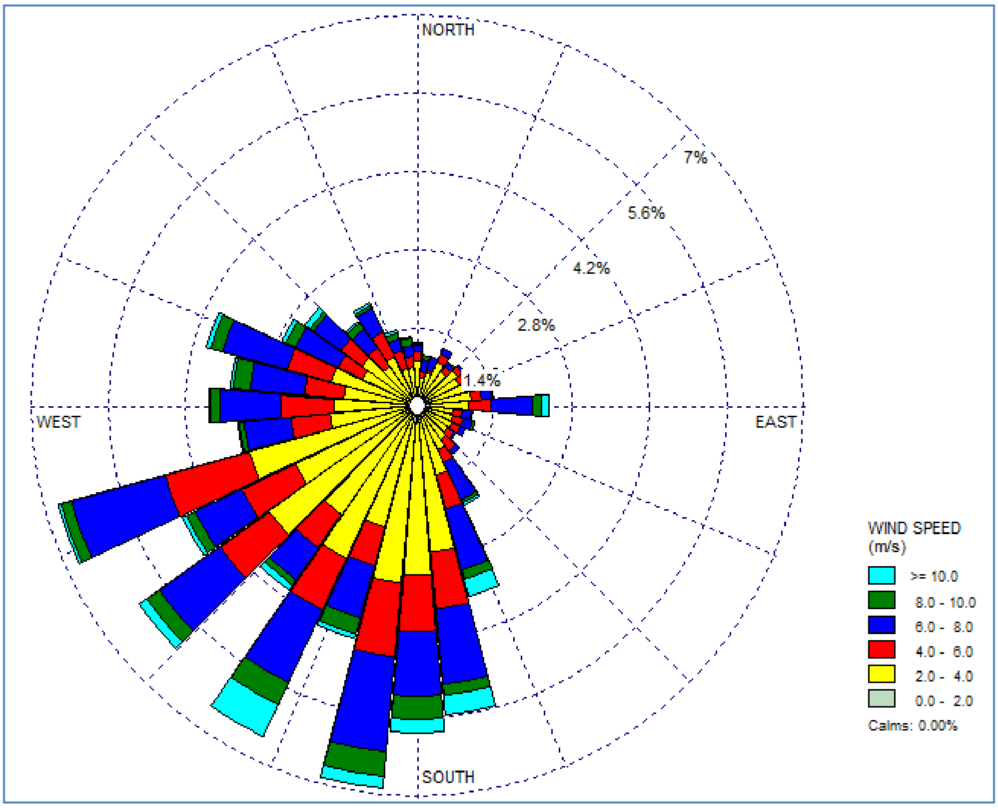


Figure 4 : Wind-rose of wind-direction and wind-speed frequency, Birr Weather Station

The wind-rose shows that the wind at the weather-station has a strong directional bias to winds coming from between the south and west, as is common in Ireland.

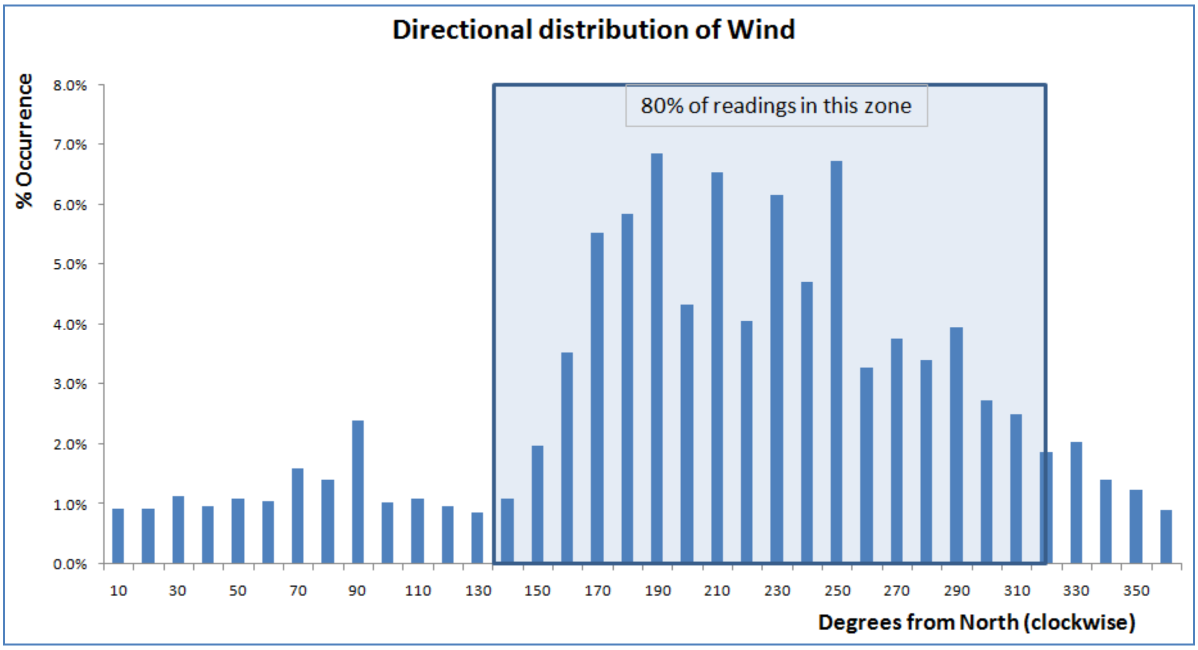


Figure 5 : Directional Distribution of Wind at Birr Weather Station (80 percentile in shaded area)

The figure above displays the same data horizontally and the shaded area indicates that 80% of all readings indicate wind coming from the semi-circle between south-east and north-west.

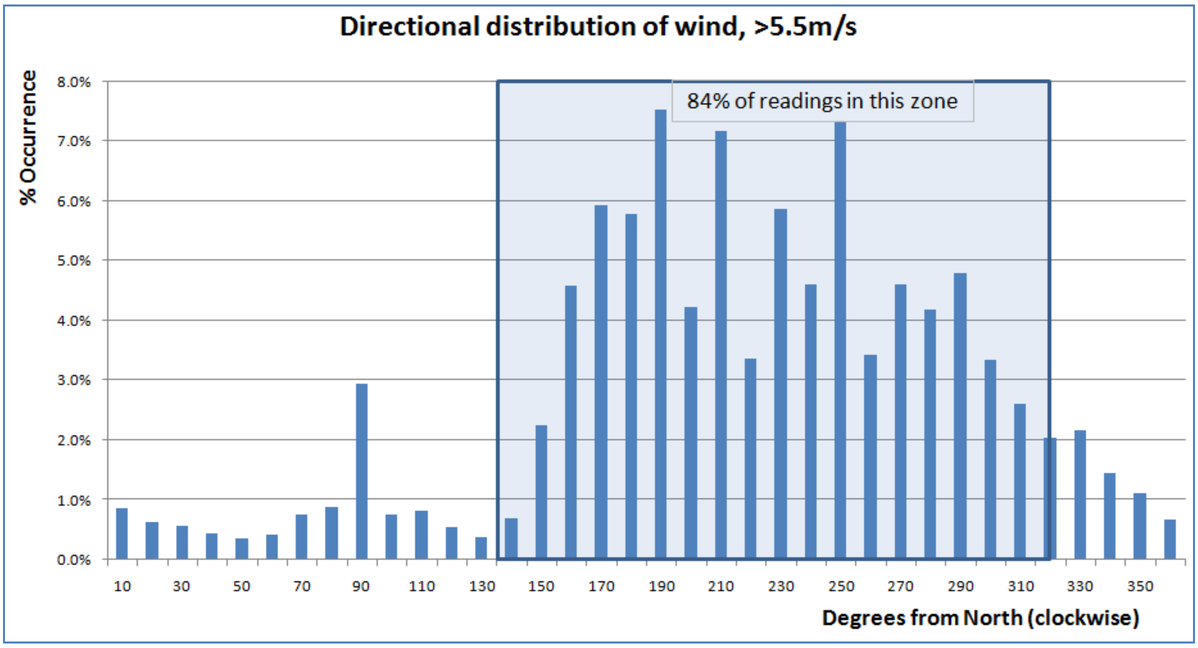


Figure 6 : Directional Distribution of Wind >4 m/s (84 percentile in shaded area)

The figure above filters to previous data to display the distribution of readings showing a wind-speed greater than 5.5m/s (adjusted), or a Class 2 wind-speed. This is taken to be the minimum wind-speed at which testing can be carried out. The data shows that 84% of all readings have wind-speeds above this threshold.

The wind-direction results are significant in that they indicate that if a test-site were of a semi-circular shape, and arc from south-east to northwest, anti-clockwise, that it would operate for 80% of the time using a landbank 50% smaller than an "ideal" circular site.

This also raises the possibility of test-flights at a higher height than would be acceptable in a 1km circular test-site as the tether bas could be offset from the centre of the circle to reach greater height while still remaining within the secure test-site from a safety perspective.

5. Design and layout of test-sites

With the prospective test-site shortlist drawn up, each of these were visited (insofar as existing access permitted) to determine if there were any other issues or factors to be taken into account in assessing the suitability of each site.

From this feedback, a test site facility has been designed and costs provided (cost breakdown has been provided in Appendix C.).

We have also provided an indication of what factors will have to be considered in the provision of an EIA as part of a planning application. The fact that the prospective sites are most likely to be worked raised bogs, will make the environmental considerations less of an issue in the submission of any planning application.

5.1. Site Visits

With the GIS work having turned up a number of prospective sites. All sites were located around the Shannonbridge/Banagher area and were wholly owned by Bord na Mona. The three sites were each visited during the course of the study to assess the on the ground conditions to those outlined with the GIS work and satellite imagery.

The selected sites straddled the Shannon River and are/were active working raised bogs. The low-slung landscape made it difficult to attain a good panoramic perspective but it did provide an excellent opportunity to understand how each site could work in the context of the existing Bord na Mona infrastructure of road, rail and siteworks.

Site no. 1 – Kiltanagh

Figure 7 :Site No.1 Kiltanagh

This was a hard site to get a good perspective on with access and perspective particularly difficult. It was also the closest to the Shannon callows which is the remaining stronghold of the Corncrake, one of the most endangered breeding birds in Ireland. The Corncrake in this area has been subject to considerable conservation efforts over the past 2 decades and while the site located on open bog land, this could become an issue if planning was applied for. We also observed a 100M tall radio mast in the vicinity of this site as well.

Again, the GIS work confirms the suitability of this site, however access for vehicles was limited on the say of the survey.

Site No.2 – Shannonbridge

Figure 8 :Site No.2 Shannonbridge

Shannonbridge from the vantage point of a small bridge, really enabled one develop a notion of where the peatworks and infrastructure of rail, and good-quality hardcore roads could combine to provide a test-site centre along the lines of that presented in the drawing designs.

The parallel roads and temporary rail network stretch into the open bog, with this site in particular providing an excellent view of the clear expanse. The second picture gives some idea of the scale of the open working space with minimal intrusion of agriculture, domestic dwellings.

Figure 9 : Site No.2 Shannonbridge

The picture above was taken from the end of the hardcore road shown in the previous photograph and almost provides a 180 degree flat open bogland potentially ideal for the location of an airborne wind energy test-site. An importance consideration in the selection of any of the sites is their orientation vis a vis the prevailing SW wind which will be a factor in the siting of the launch pads and control building.

The Shannonbridge power generating station was visible to the right of this expanse and estimated to be 3-4km away.

Site no.3 – Aughicabe

Figure 10 :Site No.3 , Aughicabe

Aughicabe was a more mixed topographically as a result of esker formations running through the site and elements of recolonisation by trees and shrubs. While the GIS work points to significant open tracks, it was difficult to make it out.

However, Aughicabe was also accessed via the Bord na Mona Blackwater site, one of the most significant engineering works in the Bord na Mona portfolio. The significance of this that the built structures on this site could be ready-made to accommodate some of the storage and workshops required in the development of a test-site. Access to this site is good and could easily accommodate articulated trucks.

From an environmental perspective, an EIA would have to be undertaken probably utilising the format for that of a terrestrial wind-farm. See Appendix A for discussion of the specific parts of an EIA that would be specific to the test-site project.

The very fact that all the chosen are brownfield sites would mitigate the environmental concerns around such a development and integrating some/most of the existing built infrastructure would minimise any difficulties in this regard.

The visit reinforced the potential of the different locations and how this topography and this land ownership/land-use would be ideal for future development. One consideration to bear in mind was the location of the Shannonbridge electricity generating station to these 3 sites, which all appear to be providing milled peat to the station. Further examination of the active and exhausted sites surrounding the Shannonbridge station would be required with the specific mapping of the Bord na Mona 'hard' infrastructure and how that might be integrated into a test-site.

5.2. Design and Layout of Test Facility

1. Introduction:

The proposal involves the development of a prototype facility for the testing of Airborne Wind Energy Systems (AWES).

The facility is designed to provide facilities for Green Technology Start Up companies who are in the process of developing a variety of AWES based on research and assessment undertaken to date. There are a wide number of approaches and configurations currently being researched in this nascent industry. Because of the nature of the differing AWES including their size and their technical requirements there is a strong requirement for a dedicated, functional, flexible test facility available all year round which is not hitherto available to the companies concerned. The current proposal is designed to meet these requirements.

2. Testing Procedure

Site:

Because of the nature of the AWES, it is imperative that the final selected site meets a number of criteria-

- Suitably spacious and remote and effectively free from habitation within certain distances to offer adequate space for all testing in accordance with good Safety, Health and Welfare procedures.
- Reasonable proximity of national access roads, ideally central to the country. For the purposes of the current proposal a typical section of bogland in the centre of Ireland has been selected as a potential site.

3. Proposed Facility:

The proposed facility is designed specifically for a process comprising the delivery, unloading, assembly, preparation, transport to test area and assessment, testing and measuring of a variety of AWES. The schedule of accommodation comprises-

i. **Access/ Parking**

- Access road with security gates connected to national road system
- An area for arrival, loading/ unloading, turning and parking of 40ft container lorries containing AWES either pre-assembled or in components suitable for assembly in workshops for transport to test areas.
- An area for parking for staff, ancillary staff, company/ testing personnel

ii. **Admin/ Reception:**

- An entrance reception/ administration area adjacent to car parking providing-
    - a) Display space
    - b) Tea area for informal meeting/ discussion
    - c) Meeting room for pre and post test meetings between facility operators and testing personnel
    - d) Staff/ director/ secretary accommodation
    - e) WC accommodation

iii. **Testing Control:**

The admin reception area is connected via lift and stairwell to a dedicated enclosed control/ viewing area on the roof of the facility, designed to allow full view of the test area and enabling test data to be prepared.

iv. **Workshop/ Technical Area:**

The primary function of the building comprises 2 No. dedicated workshop area measuring 14.1m (L) x 7.7m (W) x 4.0m (H) (area approx. 110msq each) which will have-

- Full industrial sliding/ folding door access from the loading/ delivery area, and 4m high ceilings allowing forklift or manual unloading of 40ft containers to workshop floor.
- Facilities including ceiling mounted industrial gantry with hoists and lifting equipment as applicable to allow for full unloading of units, components and assembly in situ
- Fully kitted out with appropriate work benches and machinery and component storage

- Rooflighting to maximise daylighting and optimise working conditions
- Optional openable shutters to glazing/ viewing to test areas
- Access to a connecting tool/ machine room (7.7m x 6.2m) which will facilitate all assembly or adjustment in situ, as necessary, of components to co-ordinate with test area fixings, couplings and mountings

v. **Ancillary Facilities:**

- Secure garage for all terrain vehicles, which would be kept in situ when facility is not in use.
- Generators/ switch and pump room
- Freestanding mast with wind vane, anemometer, wind sock at entrance area to
- facilitate arriving testing crews

4. Testing Area:

The building/ loading area is connected by a roadway approx. 800m -1km long to a cluster of 3-4 No. concrete test pods which are nominal 12mØ concrete discs inclined approx. 10° away from the prevailing wind and which would contain a number of adaptable fixings, couplings and winching arrangements suitable for the tethering of a variety of AWES (subject to adjustment in workshop as above).

5. Services:

Electricity: Mains power provision or an industrial generator with provision of 3 phase power to workshops and tool room. The facility could in time potentially develop a wind generated energy supply and be self powering.

Sanitary: the facility will employ a Bord na Mona Puraflo private effluent treatment system or similar.

Water Supply: from rainwater harvesting filtration, pumping and storage or from a private well supply as applicable

Surface Water: connected to rainwater harvesting system and reused as grey water and drinking water as applicable with surplus to irrigation system to green roof and adjacent ground.

6. Landscaping:

The facility is to be integrated into the adjacent landscape through weatherproofing of walls and roof, grading of soil to form banks and berms and through the provision of a green roof with external access, balustrade and viewing area and rooflights all to be planted with local flora

7. Construction:

The proposal comprises a weatherproof cast in situ or precast concrete box (approx. 59m(L) x 7.7m (W) x 4m (H)), to allow for all functional requirements on a piled or cast in situ concrete raft structure, with Corten or similar rainscreen construction on metal metal framing with insulation to outside of exposed face of concrete, and with planted green roof, external stairs, corten balustrade and rooflights and a glazed box comprising the control/ viewing room.

8. Building and Facility Design:

The building is designed to provide the essential functional and technological requirements for the testing of the AWES. Because of its unique function and potential hours of operation and particularly its potentially remote location and possibility of long unsupervised periods it is designed to be extremely robust, allowing for staff to close shutters to all glazed elements and walk away leaving a fully secured building.

The design of the building is based on a deliberate intervention in the landscape based on the notion of a bog wall comprising incised sheer face to the test area, comprising robust materials such as Corten Steel and with a grassed planted concrete warm deck roof to the facility and adjustment of adjacent earth levels to integrate the whole facility into the overall landscape in the manner of the images provided.

The following three pages of plans provide an idea of how this test site might look; the first two are aerial schematics (background provided for illustrative purposes only – does not relate to any identified site).

The final schematic show ground floor, first floor, front and side elevations of what the building structure could resemble per the specification detailed above.

A detailed preliminary budget is provided in Appendix C. The total cost (incl. of VAT) would amount to €2.5m. An alternative version, reflecting a reduced budget, has also been provided in Appendix D with a total cost of €914k.

Note: the costings presented exclude the following-

a) Site acquisition

b) Boundary treatment to full site

c) Local authority development charges

d) Local Authority planning fees, fire safety and sundry charges

e) Professional fees and costs (Nominal 12% of gross cost excl. VAT) ARC, CSE, MEE, QS, Specialist Consultants, Fire Safety, Wind Energy

f) Utility connection fees and charges where applicable

These costs could be substantially reduced if the possibility existed to locate this operation within the existing built infrastructure of some of the Bord Na Mona sites identified.

Figure 11 : Architect renderings of proposed test-site facilities.

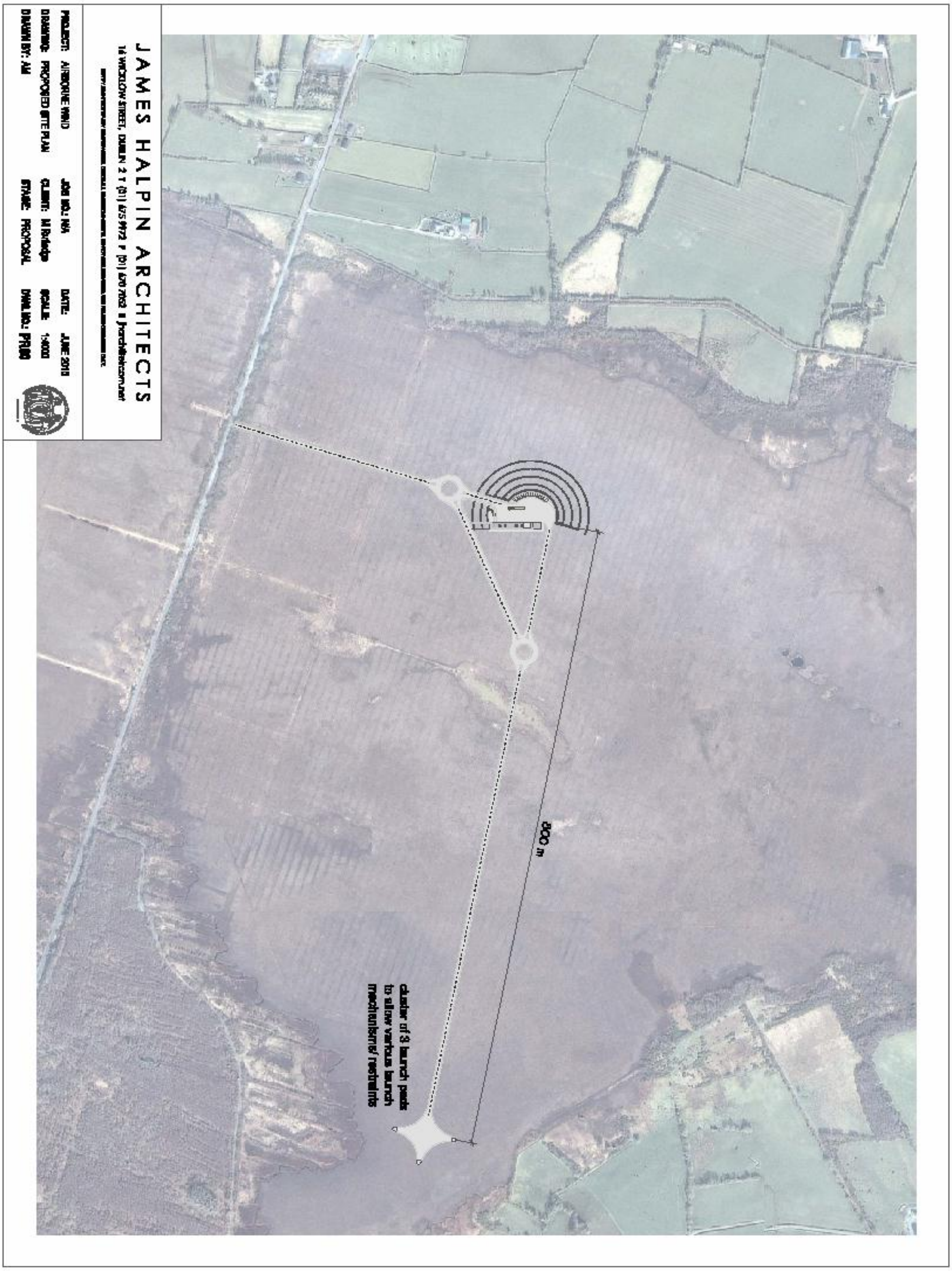


Figure 12 Aerial View of Test Facility

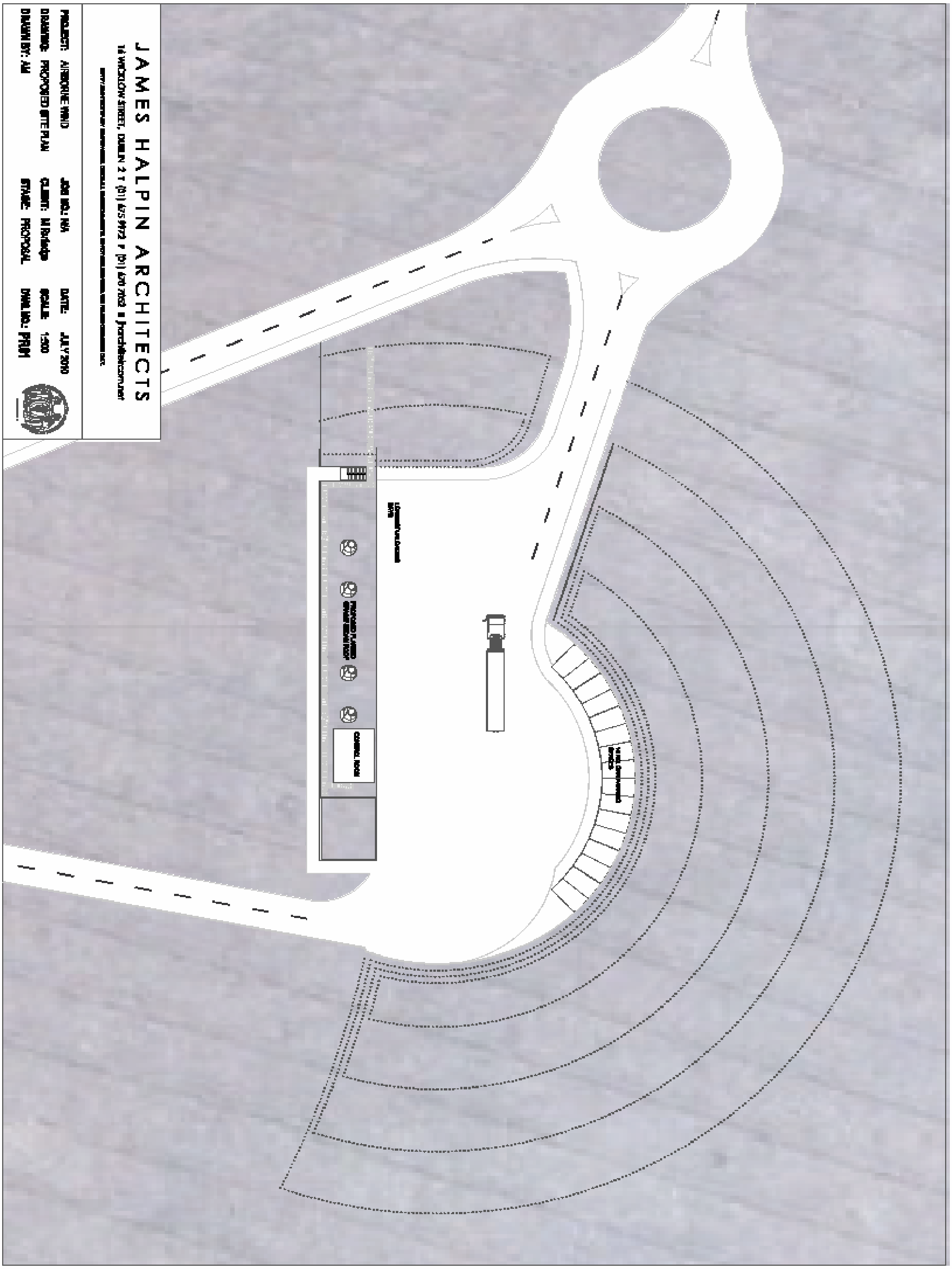


Figure 13: Access Points to Test Site

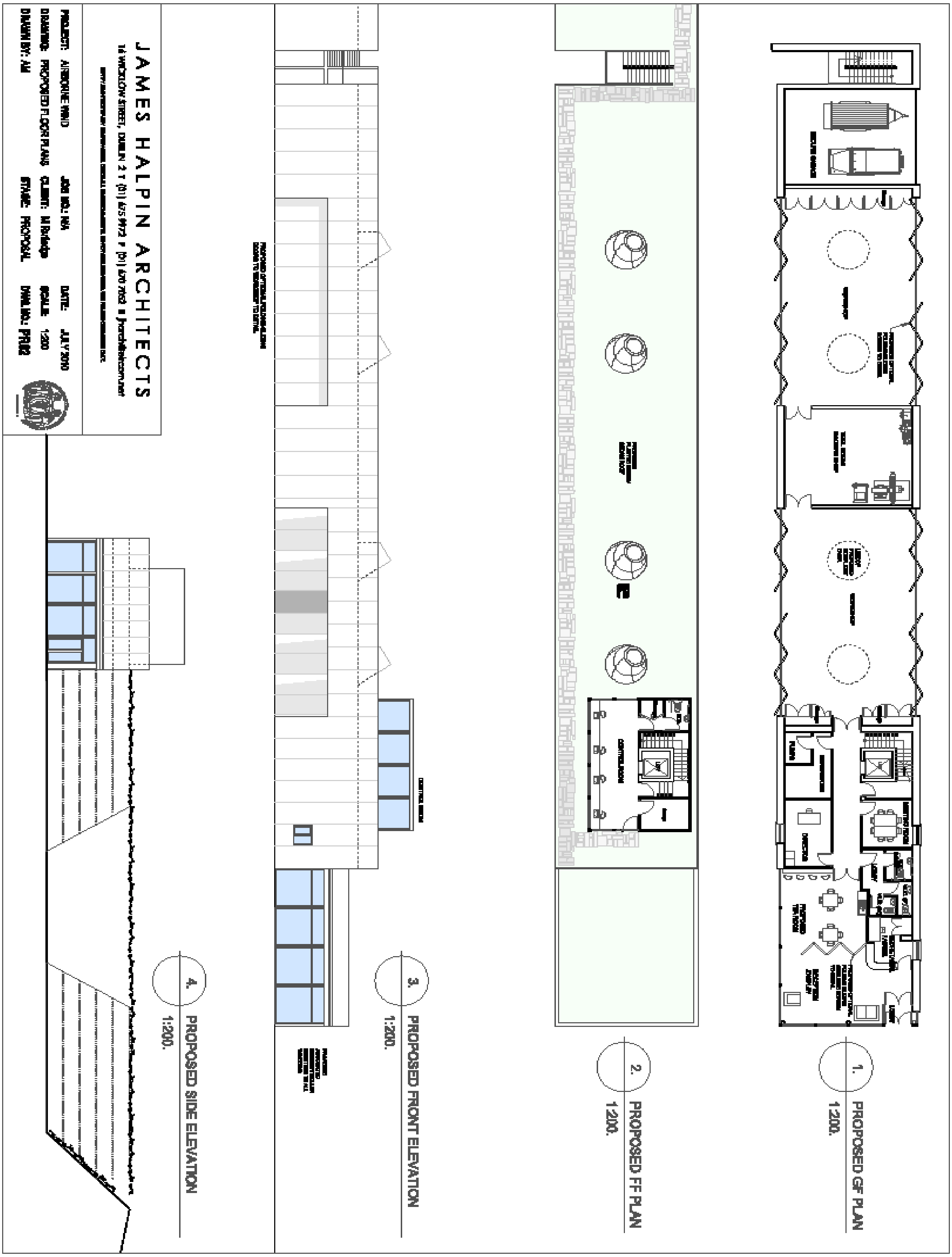


Figure 14: Elevations and Floor Plan

5.3. Environmental Impact Assessment.

An Environmental Impact Assessment (EIA) is generally required as an essential submission in any large-scale planning application. Essentially, an EIA must be conducted by the project developer before consent is given for projects likely to have significant effects on the environment by reason of their size, nature or location. While aspects of the structure and detail of the assessment may vary between countries, the EIA process and the final output of an environmental impact statement (EIS) are similar in terms of scope and intent.

Projects subject to an EIA are set out in the 5th schedule of the Planning and Development Regulations 2001 (SI 600 of 2001). Newer energy technologies do challenge the traditional categorisation under this and other legislation; a case in point is offshore wind turbines which are governed under the foreshore act of 1993.

Of the 33 development categories outlined in EIA guideline documentation, an AWE installation would fall into Project Type 33 which covers *"Installations for the harnessing of wind power for energy production (wind farms) with more than 5 turbines or having a total output greater than 5 megawatts."*

While it will be unlikely these initial thresholds will be exceeded in the early installations, the act allows local authorities to call for an EIA to be conducted for sub-threshold developments on a case-by-case basis. Given the ground-breaking nature of AWE it is likely that planning authorities would invoke the sub-threshold clause and request an EIA to be carried out. The project would be assessed under Project Type 33 as it is the only comparable category for this type of activity.

For trial purposes where the deployed kites will be temporary, mobile structures will probably obviate the need to engage with the planning authorities and just gain the necessary permit from the Irish Aviation Authority. Nevertheless, a pre-planning consultation with local authorities would be an essential exercise given the lack of precedence in this area.

Electricity, the final product of such installations, normally causes large scale linear impacts in distribution though transmission lines are usually the subject of separate applications for permission. Given the significance of potential impacts and their persistence in the environment, site selection and routing of infrastructure to the site are of great importance.

On the assumption that the local planning authorities will invoke the sub-threshold EIA requirement, the Environmental Impact Statement (EIS) will be expected to address and document the following elements in the submission:

- A description of the proposed the AWE installation, including information on its site, design and size,
- A description of the baseline environment at the site and an identification of the environmental standards which will be applied to the project,
- An identification of potential environmental impacts associated with the project,
- A description of measures envisaged in order to reduce, avoid and eliminate any adverse affects of development,
- The data required to identify and assess the main effects that the proposed development is likely to have on the environment,
- An outline of the main alternatives studied by the developer and an indication of the main reasons for his or her choice taking into account the effects on the environment,
- A description of the physical characteristics of the whole proposed development, and the land-use requirements during the construction and operational phases,
- A description of the main characteristics of the production processes including the nature and quantity of the materials used,
- An estimate by type and quantity of the expected residues and emissions (including water, air and soil pollution, noise, vibration, light, heat and radiation) resulting from the operation of the proposed development,
- A demonstration that consultations with interested parties have been carried out as part of the EIA process,

The listing in Appendix A shows, in some detail, matters for consideration under project description and environmental effects. Even if the impact on some of these sub-headers is nil, the EIS should address them individually.

The final consideration of interaction of the items in Appendix A is a very important aspect to have covered in the EIA. It assesses how the elements making up the complete project will interact rather than been reviewed in isolation. The process does not finish at the application stage, within the application there will be commitments to a regular monitoring and consultation programme both at construction and operation phases.

An AWE installation will have advantages over the traditional windfarm with more flexibility over its siting, the absence of massive permanent structures and much-reduced civil works than that required to move and site large wind turbines.

6. Development and Operation

The development and operation models for the proposed test-site contain certain unique characteristics but will endeavour to follow established practises where possible. While no similar facility exists, parallels can be drawn to existing models and support structures. Continuity is crucial to accelerating normalisation of AWE as a technology and to fast-tracking government support for the project.

During our discussions with SEAI and DCENR comparisons with the development of ocean energy were made on numerous occasions. The parallel is worthwhile since the initiative taken by the Irish government in ocean energy represents the first time, in the last 30 years, that the Irish government has taken a strategic decision to support a renewable energy technology which was as yet unproven as a commercial reality.

The Irish government initiative in ocean energy, which involved funding of €26m, can be summarised in the following actions:

- The establishment and operation of the Ocean Energy Development Unit in SEAI[5]
- The establishment of wave and tidal test facilities (full-scale test in Belmullet[6] and 1/4 scale test in Galway Bay[7]
- The enhancement of the national wave tank facility[8]
- A power-purchase scheme for electricity produced from Ocean Energy[9]
- A support fund to support research and prototype development by industry[10].

The establishment of test facilities was only one part of a broad strategy for ocean energy and the test facilities have been introduced in a phased basis, i.e. the full-scale site in Belmullet is not yet operational.

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[5] http://www.seai.ie/Renewables/Ocean_Energy/Ocean_Energy_Development_Unit/
[6] http://www.seai.ie/Renewables/Ocean_Energy/AMETS/
[7] http://www.marine.ie/home/aboutus/organisationstaff/researchfacilities/Ocean+Energy+Test+Site.htm
[8] http://hmrc.ucc.ie/facilities.html
[9] http://www.dcenr.gov.ie/NR/rdonlyres/3B13ECAA-9351-41E0-8B44-7C02E98E4F50/0/AdditionalREFITcetegories.pdf
[10] http://www.seai.ie/Renewables/Ocean_Energy/Prototype_Development_Fund/

6.1. Site Development

With an estimated cost of €2.5m, it will be difficult if not impossible to fund the development of the test-site facility entirely from private funding. It is recommended that SEAI take ownership of the test-site project and that all funding is managed by them.

Potential sources of funding are:

- Existing projects in AWE. Since the test-site proposes a valuable service to existing AWE projects, it may be attractive for specific projects to play a funding role, and thus a site-definition role in the test-site. Provision of funding in this case may be contingent on having a different level of access to the test-site when compared to non-funding projects.

- Irish Government strategic funding. Even in the current constrained environment it is likely that partial funding would be made available. This is contingent on the central role of SEAI.

- Enterprise funding. Where a case can be made for support of Irish companies or as an attraction to foreign direct investment funding, funding sources would then include Enterprise Ireland[11] and the Industrial Development Agency[12].

- Local state agency funding. Shannon Development[13] has been tasked with the creation of the Shannon Energy Valley[14] which is defined as *"A world-class cluster of sustainable energy-related activities in the Mid-West of Ireland, comprising industry & commerce, supporting services, research & development, and education."*

- EU Funding. Framework Programme 7[15] would be a potential source of funding under a number of its sub-programmes

    - Co-operation : Its remit is defined as *"supports all types of research activities carried out by different research bodies in trans-national cooperation"*. The National Contact Point is David McAuley of SEAI.

    - Capacities : Its remit is defined *as "enhance research and innovation capacities throughout Europe"*. The Higher Education Authority[16] is the National Contact Point. The Capacities sub-programme has a

[11] http://www.enterprise-ireland.com/ResearchInnovate/
[12] http://www.idaireland.com/
[13] http://www.shannondevelopment.ie/
[14] http://www.shannonenergyvalley.com
[15] http://cordis.europa.eu/fp7/
[16] http://www.hea.ie/

greater capacity to support capital-expenditure projects than the Co-operation sub-programme.

  - It should be noted that SEAI have in the past lead applications for FP7 funding.

- Private Funding. With the test-site providing a service to a large number of innovative projects in the electricity generation sector, funding may well be available from the private sector. Such funding would expect a return on its investment either via shared IP agreements or licensing agreements from participating projects.

6.2. Site Operation

It is recommended that the operation of the test-site be delegated to a university rather than having an independent operating structure. The responsibilities of the university would be :

- Administration of test-site bookings
- Administrative support to visiting projects (travel/accommodation)
- Technical support for on-site equipment (wind-measurement / IT/ workshop / communications)
- Facilities support for on-site buildings (utilities/security)
- Management of relations between visiting projects and research facilities.

The last point is crucial in that, rather than being a simple services provider, the university would also provide research-level support to visiting projects and matching the test-site facilities with research programmes within the university.

The ability of a university to provide part-time resources from their existing staff would be an advantage from an operational cost viewpoint. The responsibilities listed above would not be envisaged as being full-time initially and the required flexibility would be difficult to implement in an independent operating structure. This mode of operation is not a new one with many universities already having remote research stations/laboratories (e.g. NUIG with Mace Head in Co.Galway and Carran in Co.Clare, UCC with the Hydraulics and Marine Research Center in Cork City).

Enterprise Ireland has a Competence Centers[17] programme in place which defines a structure whereby universities provide support and facilities to commercial projects. Five such competence centers already exist, funded by €32 million from Enterprise Ireland. Four further centers are planned to open in the next 2 years.

[17] http://www.enterprise-ireland.com/CompetenceCentres/default.htm

Since proximity to the test-site would be indispensable for the managing university, contacts have been made with the National University of Ireland, Galway and University of Limerick to assess their relative suitability.

- Both universities are within one hour's drive of the three proposed test-sites.
- Both are partners in the Shannon Energy Valley.
- Both have Competence Centers on campus (NUIG for Bioenergy & Biorefining and UL for Composite Materials and Microelectronics)
- Both are already active in renewable energy research, NUIG through the Energy Research Center[18] and UL through the Charles Parsons Initiative[19]
- UL has a Chair in Aeronautical Engineering and has begun research work in AWE in 2010.

Given the aeronautical resource of UL and its previously expressed interest in AWE, it would make a better candidate for the management role in the test-site. Whether a role would be found for NUIG, via the Shannon Energy Valley, could be the subject of further discussions.

With the probably landlord being Bord na Mona and the possibility of using their buildings as well as sites, Bord na Mona would play an important role in the governance and management board of the agreed structure.

It would be of benefit to identify private companies in the area of the test-sites to directly provide services to any projects using the test-site facility e.g. engineering workshop facilities.

[18] http://www.nuigalway.ie/energy/

[19] http://www2.ul.ie/web/WWW/Faculties/Science_%26_Engineering/Research/Research_Institutes/CPI

7. Evaluation of Policy Options

The energy 'community' in Ireland is well-established with all parties conversant with the strategies, policies and personnel of each other. At the centre is the department of Communications, Energy and Natural Resources, SEAI administer policy and programmes and the broader body is made up of the state-owned energy companies and research programmes administered by DECENR.

Airborne wind energy does not form part of any official position within DCENR and SEAI; the closest pre-commercial technology would be the wave energy programme. Ireland's wave energy programme (including test site) was built up over the period of a decade with numerous strategy documents and investments. This programme has also embedded research in the 3rd level network and recognised third party investment from the likes of Vanttenfall.

This is the likely roadmap for airborne wind energy, the sponsorship of Bord Gais and possible involvement of Bord na Mona will be critical in generating the same level of sustained investment and interest.

7.1. The position of the DCENR

Minister Eamon Ryan is already quite conversant with this technology and he and his officials have already met/communicated with companies and stakeholders (Makani / Joby / Statkraft) and have expressed an interest in the development of airborne wind energy technology in Ireland. A meeting was held with Minister Ryan in his office in early July to brief him on this project and the support provided by Bord Gais to date.

7.2. The position of SEAI

A meeting was held with SEAI on July 5th, 2010. Present at the meeting were Katrina Polaski, John McCann and David McAuley from SEAI and Colm O'Gairbhith/Mark Rutledge from Carbon Tracking.

Following a general presentation of AWE technology and the BGE report, a broad discussion was held with the main points listed below:

- The main issue for SEAI can be reflected in the question: What is in it for Ireland ?
    - Does Ireland need the extra energy? i.e. do the existing RE plans suffice to meet our targets ?
    - At the moment there are no AWE companies active in Ireland. By comparison, there were 3 existing Ocean Energy companies in Ireland before the Ocean Energy Program was defined. This would weaken the case for supporting the AWE test-site.

- If the aim is merely to generate cheap renewable electricity, then current wind technology fits the bill quite nicely i.e. AWE support is not justifiable from a national project development perspective. This argument is countered by the potential to build an export-driven AWE industry in Ireland.
- Does it match the existing value-chain and capabilities in Ireland? The control system aspect would seem to be the best match but also EireComposites for materials design, links to universities such as UL for composites, links to Shorts Belfast for control systems, to Wilson Generators in Larne. SEAI consider it very important to identify the existing actors in a hypothetical supply chain for WE systems development/production.

- SEAI consider that the AWE project is at a year 2000 level of activity when compared to ocean energy. Note that no power take-off, the term used for power generated and delivered to the grid, was delivered by any ocean energy project until 2005.

- SEAI recommend following a similarly structured approach as was used for ocean energy. To this end communication with Tony Lewis and Brian Holmes of the HMRC would be useful. Ocean energy defined protocols[20] clearly the path for scale-testing i.e. CFD => 1/4 scale => mid-scale => full-scale.

- SEAI see Bord na Mona may be a potential partner but note that State companies may already have post-carbon plans for raised bogs.

- SEAI consider that a feed in tariff (FIT) is essentially a distraction and inappropriate for research activity. They consider FIT to be a PR activity and as long as this is understood by all concerned then it may be useful.

- SEAI notes that a device development fund exists as part of the RD&D[21] fund in SEAI.

- SEAI considers the main selling point to be the industrial potential, i.e. the creation of an export-based industry in Ireland both from indigenous companies (supported by EI) and FDI (supported by IDA).

- Overall, it must be demonstrated that the test-site activity is only one step in an overall strategy and it is imperative to constantly "make the case" for AWE.

[20] Ocean Energy Development Protocols http://www.marine.ie/NR/rdonlyres/870BA9C2-B58E-4230-A4BD-5CE031A276DC/0/deweprotocol.pdf
[21] RD&D fund http://www.seai.ie/Grants/Renewable_Energy_RD_D/

A second meeting was held on the same day with Owen Sweeney, who heads the Ocean Energy section of SEAI. The main points of the meeting are:

- ESB and Vattenfall are interested in the full-scale test-site in Belmullet , Co.Mayo because it allows them to enhance their understanding of how real-world installations will work. They do not have a technology-owner perspective.
- The management structure of the full-scale Belmullet site is still unknown: either Public-Private Partnership or wholly state-owned. No universities are involved in management of the site at this stage.
- The Belmullet site is strictly pre-commercial. i.e. no product development/tweaking of devices, the systems will be installed in Belmullet to allow marketing of the systems, i.e. fully operational.
- The 1/4 scale test-site[22] in Spiddal, Co.Galway, appears a closer fit to the AWE project than the Belmullet test-site. This test-site in Spiddal is managed by the Marine Institute

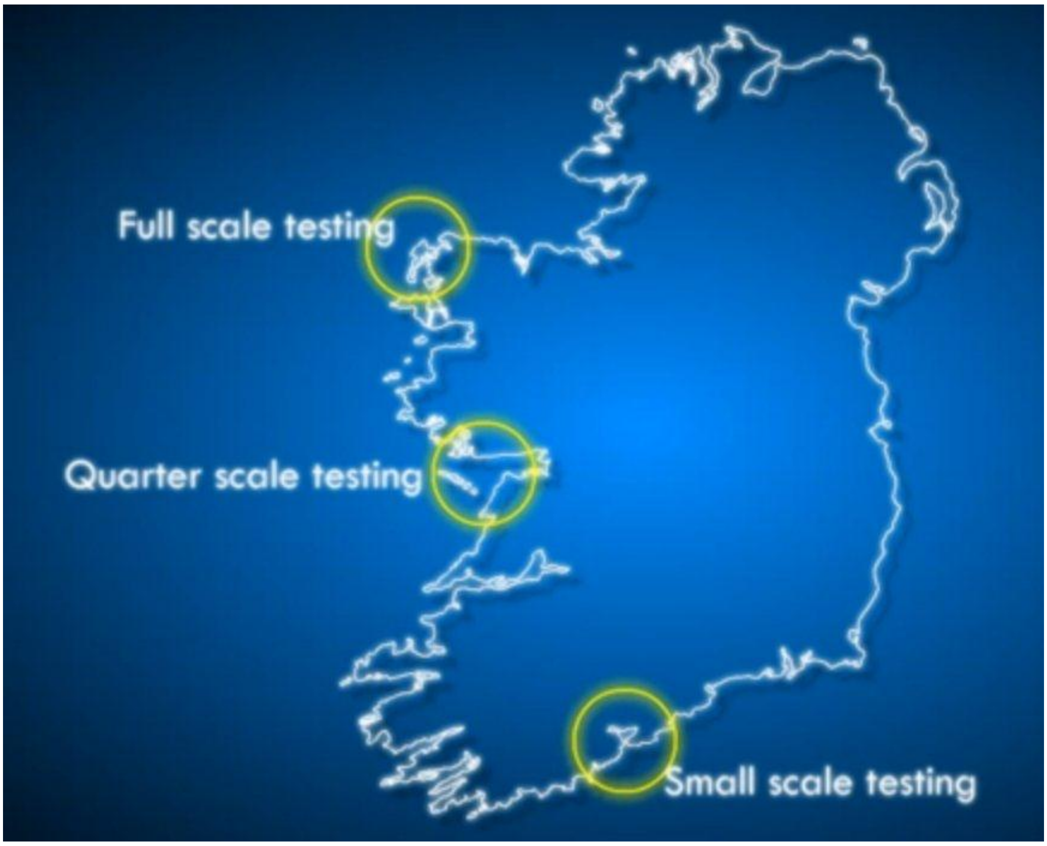
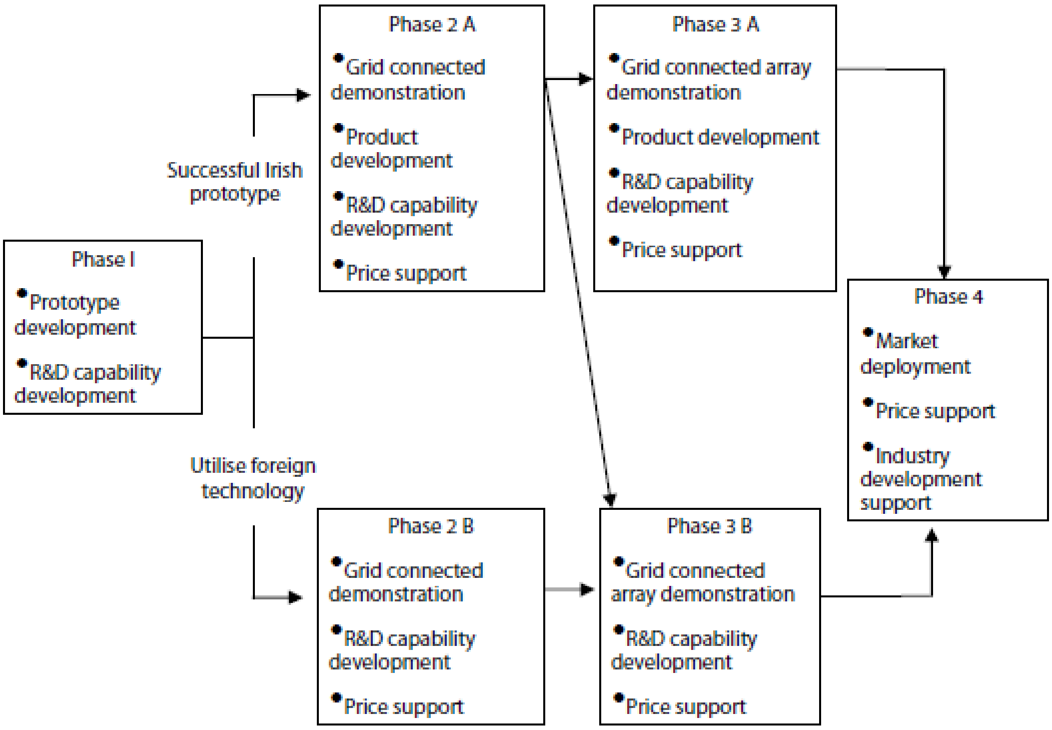


Figure 15 : Ocean Energy Test Sites in Ireland

[22]http://www.marine.ie/home/aboutus/organisationstaff/researchfacilities/Ocean+Energy+Test+Site.htm

Figure 1: Four Phase Ocean Energy Strategy



In order to implement the Ocean Energy Strategy, an Advisory Group comprising relevant parties is proposed together with a step-by-step implementation plan.

Figure 16 : Taken from pg 3 of Ocean Energy Strategy Report 2006[23].

23 http://www.seai.ie/Renewables/Ocean_Energy/Ocean_Energy_Strategy/Ocean_Energy_Strategy_Report_18082006.pdf

8. The Irish Aviation Authority

The Irish Aviation Authority (IAA) is of primary importance in the development of a test-site as defined by its responsibility to "provide **air navigation services in Irish-controlled airspace,** and to **regulate safety standards** within the Irish civil aviation industry". The IAA has the initial decision on whether a test-site will be allowed to operate or not and on the conditions that will be applied to the operation of the site and the AWE systems that use it.

Discussions have been held with the IAA with the following aims :

- Raise awareness of AWE technology and the current state of the industry to assist the IAA in making an informed judgement.
- Identify the existing legislation that is relevant to AWE technology.
- Identify the challenges that a fundamentally new technology such as AWE may pose to existing legislation.
- Identify the process by which AWE technology can be introduced under existing legislation for both a test-site with broad requirements and for specific AWE systems.

The final goal of the engagement with the IAA is to arrive at a situation where the IAA viewed AWE technology in a favourable light and to prepare future engagement in the case of a detailed test-site proposal at a specific site with a specific set of AWE technologies. The goal is not to arrive at a formal acceptance but more to ensure that there was no formal opposition.

8.1. Existing legislation

The IAA maintains and publishes a series of Statutory Instruments (S.I.'s)[24] which details current aviation-related Irish legislation.

The S.I.'s of specific relevance to AWE are:

No.806 of 2007 Irish Aviation Authority (Designated Areas) Order, 2007[25]
Article 3 of this S.I. defines a designated area as "*an airspace of defined dimensions designated by the Irish Aviation Authority with the consent of the Minister for Transport and the Minister for Defence for use by the Defence Forces. An aircraft, other than an aircraft of the Defence Forces, may not enter such an airspace without the permission of the person operating air navigation services therein;*". The designated areas from this S.I. can be seen in Figure 17 on page 53.

[24] Listing of all Aviation S.I.'s : http://www.iaa.ie/index.jsp?p=332&n=116
[25] S.I. 806 http://www.iaa.ie/index.jsp?p=93&n=97&a=225&pp=332&nn=116&lID=271

No.215 of 2005 Irish Aviation Authority (Obstacles to aircraft in flight) Order[26]
This order defines what constitutes an obstacle to aircraft in flight and details how permission for construction of an obstacle may be gained from the IAA. This requirement is separate from any permission required to be obtained for the obstacle under the Planning and Development Act, 2000.

Article 5(2) states "*A person shall not cause to be erected or constructed any object as defined in Article 4 of this Order within a radius of 10 kilometres of a licensed aerodrome without first notifying the aerodrome licensee of that aerodrome in writing of that intended erection or construction at least thirty days prior to such erection or construction and shall, additionally and where requested, provide such information in relation thereto to the Authority as may be required under paragraph (3) of this Article.*"

If an AWE test-site is located outside the 10km radius of an aerodrome then it would be considered an "*en-route obstacle*" which is defined, in Article 2, as "*an object outside the airspace defined by aerodrome obstacle limitation surfaces, extending to a height of 90 metres or more above ground or water surface level at the site of the object, thereby having significance for the en-route operation of aircraft*".

Article 5(3) states "*The Authority may require a person as specified in paragraphs (1) or (2) of this Article to make available to it information relating to an obstacle, including its geographic latitude and longitude, elevation and height.*"

Article 6 states "*The Authority may require the marking and lighting of an obstacle defined in accordance with Article 4 of this Order in accordance with such instructions as the Authority may give in a particular case.*"

No.492 of 2009, Irish Aviation Authority (Noise Certification and Limitation) Order[27]
Article 15 states "*The Authority may exempt a class or classes of aircraft by direction from a provision of this Order.*"

No.324 of 1996 Irish Aviation Authority (Airworthiness of Aircraft) Order[28]
According to Article 7(1) of the S.I., no aircraft shall fly, or attempt to fly, unless it has a certificate of airworthiness from the state in which it is registered or has received a written "*flight permit*" from the IAA. The definition of "*aircraft*" for the S.I. is "*any machine that can derive support in the atmosphere from the reactions of the air other than the reaction of the air against the earth's surface*" and would include all AWE technologies.

Article 7(2) states that Article 7(1) "*shall not apply to a glider, unmanned balloon, unmanned model aircraft or kite which is neither a public transport aircraft nor*

[26] S.I. 215 http://www.iaa.ie/index.jsp?p=93&n=97&a=225&pp=332&nn=116&lID=272
[27] S.I. 492 http://www.iaa.ie/index.jsp?p=93&n=97&a=225&pp=332&nn=116&lID=744
[28] S.I. 324 http://www.iaa.ie/index.jsp?p=93&n=97&a=225&pp=332&nn=116&lID=292

an aerial work aircraft and which is used solely on flights beginning and ending in the State without passing over any other state."

This would obviate the requirement to provide a certificate of airworthiness or flight permit for such AWE technologies as fit that definition.

Further definitions of relevance provided in Article 2(1) of this S.I. are :

"*balloon*" means a non-power driven lighter-than-air aircraft;

"*glider*" means a non-power-driven heavier-than-air aircraft which derives its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight;

"*kite*" means a non-mechanically-driven aerodyne which (a) is supported in flight by aerodynamic reactions on surfaces remaining fixed under the same conditions of flight; and (b) is moored to the ground;

No.422 of 1999 Irish Aviation Authority (Tethered Balloons, Airships, Free Balloons and Kites) Order[29]

Article 4 states "*A balloon in captive or tethered flight, or a kite, shall not be flown within 150 metres of a cloudbase or higher than 60 metres above ground level, measured to the top of the balloon. Where it is proposed to tether a balloon of total height 45metres or more, the Operating Standards Department of Authority shall first be advised at least 24 hours beforehand.*"

These apparent restrictions are treated further in section 8.2.

In addition to the marking/illumination requirements given in Article 6 of S.I. 215, this order defines, in Article 7 that "*A tethered balloon or kite shall not be flown at any location by any person between sunset and sunrise without the permission of the Authority and the balloon or kite and the associated mooring lines shall be lighted in accordance with such conditions as are specified by the Authority in giving such permission.*"

Article 8 states that "*A tethered balloon or kite shall not be operated between sunrise and sunset unless the associated mooring lines have coloured pennants or streamers attached at not more than 15 metre intervals, beginning at 45 metres above the surface of the earth and visible for at least 2 kilometres.*"

The Irish legislation is very similar to the UK equivalent, The Air Navigation Order 2005[30].

The IAA also publishes and maintains a set of documents referred to as the Aeronautical Information Publication[31]. These documents provide data on all aerodromes, designated areas, en-route obstacles and charts/tables.

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[29] S.I. 422 : http://www.iaa.ie/index.jsp?p=93&n=97&a=225&pp=332&nn=116&lID=290
[30] Air Navigation Order : http://www.opsi.gov.uk/si/si2005/20051970.htm#97

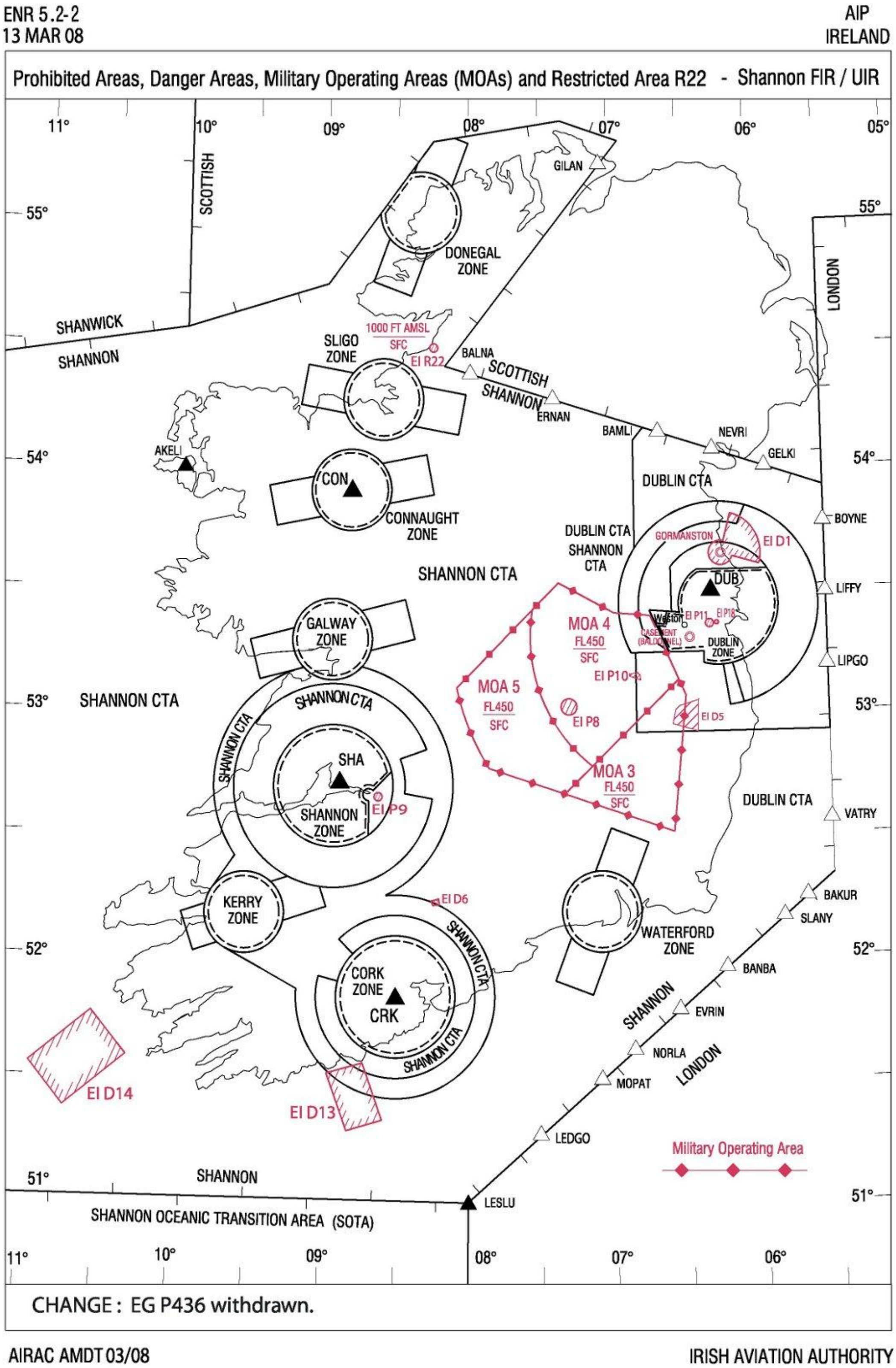

Figure 17 : Flight Restricted Areas[32]

[31] Available on the IAA web-site : http://www.iaa.ie/safe_reg/iaip/aip_directory.htm
[32] All Flight controlled and restricted areas : http://www.iaa.ie/safe_reg/iaip/Published%20Files/AIP%20Files/ENR/EI_ENR_5_2_en.pdf

8.2. Site-definition / Flight Permission

In discussions with the IAA a generic test-site was used as a basis for discussion. This generic test-site had the following characteristics:

- Located outside of controlled airspaces as detailed on Figure 17 : Flight Restricted Areas.
- Requiring a maximum flight height of 600m corresponding to a restricted area on the ground with a radius of ~1000m.
- Varied flight-lengths and times up to 24 hours maximum at any time of the day or night. Allow for consecutive flights.
- No specific detail was given for a proposed AWE system with a number of different technologies presented.

The persons contacted in the IAA for the purpose of discussing test-site definition and flight permissions for AWE systems were:

- Tony Harkin, Aeronautical Officer with responsibility for parachute permits, balloon permits, aerial/flight displays and unmanned air vehicles.
- James O'Sullivan, Aeronautical Officer with responsibility for designating temporary restricted areas (TRA) and issuing temporary notifications regarding TRAs and temporary obstacles referred to as Notice To Airmen or NOTAM's.

The reaction from the meetings was positive, with no opposition to the AWE concept encountered.

The IAA position was that handling of request for periodic flight permissions for AWE systems could be met under the existing procedure for handling tethered balloons. The requirements for each flight are:

- Co-ordinates of the tether base in WGS-84 format
- The altitude of the tether-base, measured in feet above mean sea level (AMSL)
- The maximum height to be attained by the AWE system
- Whether the AWE system, including the tether, is marked/illuminated. This matter is treated further in section 8.3.

This information could be provided to either Tony Harkin or James O'Sullivan and they indicated, that for a temporary request, a response could be expected with

24 hours. Mention was made of the risk that in case of the absence of both (e.g. holidays/sickness.travel) granting of permission might be delayed.

For requests for periodic flight permission, IAA highlighted two methods of authorisation which could be used :

- Temporary Restricted Airspaces (TRA). This can be either used to exclude all aircraft or to allow specific traffic in the zone. Where specific traffic is allowed then there must be an internal air-traffic control structure in the zone. Normally this is used for events such as airshows, race meetings, events involving foreign dignitaries. Currently, the IAA have created TRA's of a maximum duration of 2 weeks.

- Notice to Airmen (NOTAM). NOTAM's are issued to aircraft operators and indicate what if any temporary obstacles exist in a given zone. It is the responsibility of aircraft operators to consult the most recent NOTAM's and to operate accordingly.

While the flight heights mentioned were well beyond those specified in the S.I. 422 (limited to 60m above ground), the IAA can allow flights above this height in the case of a written flight-permit request.

Safety concerns
While a certificate of airworthiness is not required for the AWE systems presented, see S.I. 324, safety issues relating an eventual loss of control were raised by the IAA. They consider that loss of control may occur either through the severing of the tether or through a malfunction of the active control component of the AWE system. They gave an example, for a tethered balloon, of a pressure patch that is automatically detached at a certain altitude causing the slow descent of the balloon in the case of a severed tether. Their position is that a failsafe landing mechanism was a minimum condition for granting of a flight permit.

Each different type of AWE systems would need to meet with IAA's satisfaction separately, and no blanket permission could be given for a specific test-site.

A Permanent Fly-Zone
For the creation of a permanent fly-zone, the same information must be provided to the IAA as for a temporary request :

- Co-ordinates of the tether base in WGS-84 format

- The altitude of the tether-base, measured in feet above mean sea level (AMSL)

- The maximum height to be attained by the AWE system

- Whether the AWE system, including the tether, is marked/illuminated. This matter is treated further in section 8.3.

If the proposed site is within military airspace ,as defined in S.I. 806, then the IAA will defer initially to the Irish Defence Forces (contacts is Leftnt Colonel Ray Martin, Casement Aerodrome, Baldonnel).

The IAA will also consult with their technical staff to ascertain what effect, if any, the test-site might have on navigation equipment (i.e. spurious readings from radar due to rebound). A similar request to the Dutch Aviation Authorities[33], made by Ampyx Power, has indicated that their system does not negatively impact on navigation equipment. This would need to be verified for each type of AWE system.

The IAA will also contact the relevant local authorities in the case of a permanent fly-zone request. Pieter Van Velzen is the IAA liaison to local authorities.

Once permanent fly-zone status is granted, a symbology is created to represent the specific nature of the site and the site will appear on all future aviation charts.

8.3. Lighting Requirements

In order to ascertain the lighting/illumination requirements for AWE systems, a meeting was held with Brendan King, IAA.

A generic test-site, as described in section 8.2, was presented. At this stage the IAA then took the position that an AWE system would represent an "en-route obstacle" (see S.I. 215). The lighting requirements for en-route obstacles are defined in Annex 14 to the convention on international civil aviation, Volume 1 "Aerodrome design and operations" (July 1999), referred to as the "Chicago Convention". This annex states the following :

- En-route obstacles over 90m but less than 150m in height need to carry medium-intensity lighting.
- En-route obstacles over 150m need to carry high-intensity lighting.

This lighting requirement is originally specified for fixed structures, i.e. chimneys, bridges, buildings. From the IAA viewpoint an AWE system, including its tether, represents a comparable risk to aviation and would need to be similarly lit, both the tether and the flying component.

[33] Jure Zrilic, Statkraft. Direct anecdotal evidence July 26th 2010.

Such a position may pose a serious challenge to an AWE system as the extra weight penalty imposed on a flying structure which, by essence, strives to be as light as possible, may render some AWE technologies inoperable.

Rather than push the IAA further into a position which was beginning to appear unfavourable towards AWE systems, the discussion was taken in a broader direction but the issue of lighting remains unresolved at the moment.

8.4. Conclusions

The engagement with the IAA on understanding the process which would be used to set up and operate a test-site was positive. Existing processes can be used and no procedural difficulties were encountered.

Safety related issues, which are specific to each AWE system, were discussed in a general manner and the conclusion is that each AWE system would need to satisfy the safety requirements as defined by the IAA but would not need a certificate of airworthiness. This makes the process somewhat less onerous for the distinct AWE systems.

The issue of lighting requirements remains unresolved and represents the most serious obstacle to the creation of a test-site. When compared with corresponding legislation in the UK[34], the lighting requirement, as initially stated by the IAA, is far more onerous. It may be assumed that the restrictive nature of the IAA requirements is due to the possibility that the IAA does not have the same accumulated experience, in the domain of balloon/kite, as its UK counterpart. In future discussions the differences between the UK and Irish legislation in this regard could be highlighted in a sensitive manner.

If the test-site project is to advance further it may be of benefit to propose a trip for IAA personnel to visit the Dutch Aircraft Authorities and also assist at a demonstration flight at Ampyx Power and TU Delft. This would serve to help their understanding of AWE technology. Since AmpyxPower is currently engaging with the DAA, a meeting between IAA and DAA on this subject may allow the IAA to use Dutch precedent to facilitate a favourable decision on IAA requirements for AWE test-flights.

34 http://www.statutelaw.gov.uk/content.aspx?LegType=All+Legislation&PageNumber=1&NavFrom=3&parentActiveTextDocId=3449066&activetextdocid=3449374

9. Conclusion/Recommendations

This detailed report has, we believe, demonstrated the overwhelming level of interest among the airborne wind energy industry for the development of a common test-site. 100% of respondents stated that such a facility would be *"useful"* or *"very useful"*.

The report also identifies potential locations in the Midlands and provides a budgeted design for the build and operation of the test site.

Whether airborne wind energy will be a full-blown commercial success or not is too early to say. We believe the technology possesses certain benefits that will ensure it occupies a defined niche in the low-carbon world. We would also contend that the benefits accrued and risks associated with commercialisation are no greater and probably less (lower capital, etc.) than the marine energy industry.

The marine energy sector in Ireland has benefited from successive government support and the structures and governance put in place initially by the Marine Institute and latterly by SEAI with the succession of studies and blueprints put in place which has guided the industry for almost 10 years. The marine industry also developed its' academic champions which served to underpin the strategies adopted.

Airborne wind energy is really at the very start of this scale of endorsement. Under the patronage of Bord Gais and Statkraft, initial work, including this report has been undertaken to begin to shape a similar blueprint plan to that adopted by the marine energy sector.

For this facility to succeed, it will require the sponsorship of this technology to extend to Bord na Mona. Even before the GIS surveys were undertaken, we intuitively felt that the best site prospects would be Bord na Mona locations. The dissipated settlement patterns and fractured land ownership configuration would have made identification of other suitable sites extremely unlikely.

Bord na Mona hold the key in the provision of a suitable test-site from its extensive landbanks in the midlands. At a time when Bord na Mona is viewing a wide range of low-carbon alternatives, their involvement would coincide well with the overall thrust of their 'Contract with Nature' strategy. There is also positive advantage in the fact that Bord na Mona, Bord Gais and SEAI all fall under the same ministerial reach in DCENR, this would assist in creating a natural alignment among the stakeholders.

The authors also believe that the development of a test-site would serve as an excellent high profile project for the much publicised Shannon Energy valley concept. Its probable location close to the Shannon and its 'world's first' attribute would create an excellent narrative and springboard for further developments. It should be borne in mind that the startup costs of this facility should be no more than €3M with an annual operating budget of approximately €500K per annum.

This is not a vanity project or a white-elephant, this is a necessary piece of infrastructure that the AWE sector will need to develop and move their product to commercialisation. While we lament that Ireland Inc. was never able to obtain a piece of the development and manufacture of the commercial onshore wind energy sector, we have been presented with a chance to position ourselves at the centre of the next generation wind energy technology. Concerns about the costs need to be put into context when we spend €10m per kilometre on motorways in Ireland.

At a time when job creation is paramount, Ireland Inc. needs a flagship project in the Greentech area. The creation of a test site will kick start a modest but important inward investment programme as companies seek to conduct R&D, fabrication and testing, and locate their EMEA operations of our Ireland.

Key pieces of infrastructure or taxation regimes have always spurred on inward investment waves. In the medical device industry the development of Ethylene Oxide and Gamma sterilisation facilities in Ireland were the precursor of significant inward investment from a large number of multinationals. We believe that the development of the world's first AWE test-site would serve a similar role based on the “build it and they will come” principle.

The difficulty with allowing it evolve under the normal timelines is the early adopter advantage will be lost and another country will put in place a serviced test-site and win the attendant inward investment that would follow.

At an immediate practical level, SEAI should be handed over the responsibility, in conjunction with the IDA, to make Ireland the destination of choice for all activities related to AWE.

As an immediate start, we believe that SEAI should look to sponsorship a global conference in Ireland with the assistance of BGE, BNM and Statkraft. This conference should also include a fly off for some of the pre-commercial devices and really garner the level of interest of utilities, Greentech investment funds and the start-ups themselves.

Appendix A. Environmental Impact Assessment

INTRODUCTION

These projects vary in scale – both in terms of the number of turbines and their height. The size, movement and appearance of these structures present challenges that are unique to this project type.

Project Description

Checklist of the items to be described (consider that this was designed with static wind turbines in mind but nevertheless applicable for high-altitude wind energy):

Construction

- Site access – permanent and temporary;

- Road transportation works – for moving very large loads;

- Site development – drainage, trenching, spoil disposal;

- Materials – sourcing, quantity, storage;

- Construction / erection; techniques /phasing / duration / timing;

- Grid extension and connections.

Operation (Including relevant alternatives)

- Lifespan components / lifecycle;

- Rotation speeds, direction, speed;

- Operational characterisation noise, flicker, electromagnetic interference

Decommissioning (If applicable)

- Removal of non-functioning structures and rehabilitation of associated structures.

Growth

- Planned extension / upgrading.

Associated Developments

- Upgrading or provision of new grid connections, substations or other supporting infrastructure.

Environmental Effects

Typical significant impacts likely to affect the following:

Human Beings

- Flicker effects (nuisance and human health);
- Television reception;
- Affects on amenities (residential and tourism).

Fauna

- Disturbance during construction;
- Avoidance by sensitive species.

Flora

- Habitat disturbance during construction.

Soils (and Geology)

Water

- Disturbance of drainage and water courses during construction.

Air

- Noise;
- Airborne signals (T.V., microwave, radar).

Climate

The Landscape

- Visual impact of height and movement of turbines, access roads, grid connections and substations;
- Change of natural character in undeveloped areas.

Material Assets

- Grid capacity / access road capacity (large construction loads).

Cultural Heritage

- Effects on monuments and archaeological/cultural landscapes.

The interaction of the foregoing

– The interaction of noise, visual impacts, access to underdeveloped areas and effects on ecology can combine to affect perceptions of the integrity of natural

areas.

Possible Mitigation Options

– Site selection to avoid intrinsic sensitivity is the principal mitigation option for this project type.

– Site layout to achieve appropriate orientation and alignment is an appropriate

secondary measure

– Utilisation of non-disruptive construction methods for access roads, buried cables and other site works can significantly ameliorate impacts on water, soil, ecology and archaeology.

Appendix B. GIS Procedure for Modelling Potential AWE sites

DUE TO THE SIZE OF THE FILE, THIS SECTION HAS BEEN PREPARED SEPARATELY BUT WILL BE INCLUDED IN THE PRINT COPY OF THE REPORT.

Appendix C: Preliminary Cost Budget for Test Site – Full Version

The following are guideline costings for the development of a proposed facility. The costings are preliminary only and would require adjustment subject to detailed appraisal of proposed facility and actual selected site including-

i. Length of access road to national route

ii. Ground conditions; assessment of areas of site for building, parking and roads

iii. Security considerations

iv. Appraisal of site with respect to access, services, including water, power, sanitation

Note: the costings presented exclude the following-

g) Site acquisition

h) Boundary treatment to full site

i) Local authority development charges

j) Local Authority planning fees, fire safety and sundry charges

k) Professional fees and costs (Nominal 12% of gross cost excl. VAT) ARC, CSE, MEE, QS, Specialist Consultants, Fire Safety, Wind Energy

l) Utility connection fees and charges where applicable

Preliminary Costings:

I. Construction of Building

Area of building	m^2
Reception/ Display	
Secretarial, WCs, meeting	163
Circulation	
Generator pumps	14
Workshop 1	114
Workshop 2	114
Tool Room	48

Garage	48
External Stairs	17
Control Room	24
Total Gross Floor Area (GFA) of building	550.5

Cost of development based on RIAI basic cost guidelines for Industrial building using traditional material and construction methods on “Greenfield” site with basic finishes and services €900-€1350 per msq.

Assuming non standard construction, site conditions, external finishes, green roof, Corten facade say €1800 per msq

Total Construction Building excl. VAT **€990,000**

II. Site development works:

Note the figures below are based on assumption about reasonable ground conditions and are subject to detailed appraisal of site.

		m^2	€/ m^2	Total
a)	Access Road from junction with public road			
	Nom. 400 lin.m x 4.5m wide	1800	80	€144,000
b)	Car Parking/ loading area incl. excavation/			
	Build up/ drainage	2200	70	€154,000
c)	Road access to test sites (main road and spur to			
	entrance including McAdam surface)			
	say 800+150 lin.m x 3.6m wide	3240	80	€259,000
d)	4 No. test areas approx. say 35msq each	300	100	€30,000
e)	Earthworks, landscaping, berms, green roof, say			€40,000
f)	Security, gates, external lighting, signage, say			€15,000
Total site development works say				**€642,000**

III. Services:

a) Bord na Mona Puraflo or similar private effluent

	treatment system incl. drainage percolation area	€10,000
b)	Extra over water supply, well, rainwater harvesting, filtration, storage	€8,000
c)	Extra over surface water drainage, soakpits	€6,000
d)	Extra over, generator, 3 phase power, pumps, fuel store, bund walls, etc. say	€20,000
	Total Services say	**€44,000**
IV.	**Equipment/ Fitting Out:**	
	Specialist Equipment (Mast, anemometer, LIDAR etc.)	€250,000
	Main gantries including supports, winches say	€12,000
	Tools/ Machinery/ equipment PC Sum say	€30,000
	Test areas, fittings, winches launch equipment PC Sums say	€6,000
	Total Equipment/ Fitting Out say	**€298,000**
Total I-IV say		**€1,980,000**
V.	**Contingency sum say 12%:**	**€237,600**
Total I-V say		**€2,217,600**
+ VAT @ 13.5%		**€299,376**
Overall **Total**		**€2,516,976**

Appendix D: Preliminary Cost Budget for Test Site – Startup Version

Given the early stage nature of the technology the uncertainty around funding, we met with our architect and quantity surveyors to establish preliminary budget costings for the facility based on significantly simplified construction, reduction of potential site works.

A breakdown of figures is included; we would emphasise the preliminary nature of these and assume based on our discussions that a body such as Bord na Mona could provide a suitable site that would already contain-

v. Some of the required infrastructure such as access roads with connections to national routes.

vi. On site roads/ track-ways sufficient to allow the transport and delivery of test units to test pods.

vii. Sufficient security, existing defined boundaries to minimise extent of security fencing/ gates.

The figures also assume-

i. Extremely basic portal frame warehouse/ industrial unit for main building functions

ii. Portacabin/ temporary structure for admin facilities

iii. Minimize car parking/ landscaping

iv. Standard structural conditions (not entirely likely in a bog setting) and a contingency is included.

<u>Preliminary Development Cost:</u>

1. **Building**

- Main delivery, storage, testing, building.

  Nominal steel portal frame structure, insulated metal.

  Area = 355m^2

  Cost per m^2 = €725.

  Total = €257,375

- Admin/ office buildings

  Portacabin type structures

Purchase say 110 m^2	€58,000
Cost of preparation hard standings	€20,000

2. **Infrastructure**
    - Infrastructure (adjustment work to existing roads (subject to site detail) work to hard standings — €100,000
    - Work to boundaries, security fencing, signage, gates, lighting, landscaping — €70,000
3. **Services**
    a) Puraflo system or similar and installation and foul drainage system — €25,000
    b) Electricity Generator/ assuming not available in sit and main supplies — €25,000
    c) Surface water and soakaways — €15,000
    d) Nominal gas fire boiler system — €15,000
    e) Well systems and filtration and supply — €20,000
    f) Phone (no fixed line)
4. Equipment fitting out — €75,000

Subtotal	€700,375
+ Contingency sum say 15%	€105,056.25
	€805,431.25
+ Vat @ 13.5%	€108,733.21
Total	**914,164.46**

The above figures are preliminary only for initial budget discussions and assume site selection and criteria as per discussions and exclude-

1) Professional fees
2) Planning and development charges
3) Connection charges/ utilities

4) Loose furniture and fittings

5) Specialist equipment (Access this through relationship with 3rd level institution)